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A

TEXT-BOOK OF ANATOMY

BY

AMERICAN AUTHORS.

EDITED BY

FREDERIC HENRY GERRISH, M.D.,

PROFESSOR OF ANATOMY IN THE MEDICAL SCHOOL OF MAINE, BOWDOIN COLLEGE.

SECOND EDITION, REVISED AND ENLARGED.

ILLUSTRATED WITH 1003 ENGRAVINGS IN BLACK AND COLORS.

QUAE PROSUNT OMNIBUS

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PREFACE TO THE SECOND EDITION.

Two years have sufficed to exhaust the very large first edition of this work, and have brought to those responsible for its existence an early and gratifying sense of professional approval. The test of success is comprehensive, and may be fairly construed as including the execution of the book, about which misgivings were pardonable, and its plan, about which there was a reasonable degree of confidence. In their work as teachers of anatomy the authors had long felt the need of a text-book presenting the essential facts of human structure, and judiciously avoiding the unimportant and exceptional. Between the extremes, represented on the one hand by pocket manuals, with their flavorless condensation, and on the other hand by encyclopedias of universal inclusiveness, there is room for a work of convenient size, sufficient to contain in systematic array those portions of anatomical knowledge which are necessary to the intelligent study of physiology, surgery and internal medicine. The logical limits of this field excluded the much greater collection of facts having no known practical bearing, or only the rarest application.

The authors have unceasingly endeavored to facilitate the work of both student and teacher. Both are tested in every examination, and particularly in those conducted by State Licensing Boards. Accordingly, from the vast accumulations of anatomical science those portions have been selected which are likely to be of actual service to the student in his subsequent study, and to the practitioner in his clinical work. Emphasis has been laid upon the most important facts, obscurities have been clarified, the greatest amount of help has been given in the parts which are most difficult to learn, and everything has been illustrated by all available methods. In short no effort has been spared to promote facility of acquisition and permanence of the knowledge gained.

The arrangement of the book is along familiar lines, the ordinary divisions of systematic anatomy having been followed in the main. Each author has set forth his subject in such manner as experience has shown him to be profitable. Great relative stress has been laid upon visceral structure, without neglect of other branches; surface anatomy has received attention more in proportion to its usefulness than is usual, and the pictorial and diagrammatic illustrations (thanks to the remarkable liberality of the publishers) are phenomenally abundant and of striking artistic excellence. Wherever practicable the names of the parts have been engraved directly upon them, a method which has the great advantage of conveying at a glance their shape, position, extent and relations.

It is believed that the plan of giving directions for dissection in a separate chapter will prove a marked convenience to the student.

These characteristics of the work may fairly be credited with its adoption in a

large number of medical schools, and its extensive use by students and practitioners on both sides of the Atlantic. The early opportunity for revision, created by this demand, has been faithfully utilized, every section having been critically examined for possible improvement. Such changes have been made as were rendered necessary by the progress of anatomical science, and new matter has been added wherever desirable and consonant with the general scope of the work. Particular attention has been bestowed upon relational anatomy. Instead of the schematic device previously employed for showing the relations of the principal arteries, a series of horizontal sections at different levels has been prepared, the various parts being labelled directly with their names wherever feasible. By this plan greater precision is attained, and the facts are presented in a manner especially promotive of prompt comprehension and enduring retention. These same transections will be found equally useful in regard to the relations of other structures—nerves, muscles, etc.

In matter of illustration, a number of figures have been replaced with others seemingly better adapted to their purpose, and new pictures have been liberally added. The chapter on Osteology, for example, has been enriched with a series of drawings displaying the areas of attachment of muscles to bones, which should prove useful. The addition of new engravings brings the total above one thousand, a very large proportion being in two, three, or four colors.

It is hoped that the improvements in this edition, of which a few have been mentioned, will still further increase the favor already bestowed on the work.

F. H. G.

PORTLAND, MAINE, September, 1902.

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A
TEXT-BOOK OF ANATOMY.

INTRODUCTORY.

BY F. H. GERRISH.

Definition of Anatomy, and Divisions of the subject.—Names and Delimitations of Surface Parts.—The Systems of Organs, and their Functions.—The Order of Topics.—Methods of Study.

ANATOMY is the science of organization. It treats of the structure of organized beings. Not all of the beings in the world can properly be said to have a structure. We may speak of the structure of a flower, however simple, but we never associate the idea of structure with a crystal. The flower has petals, and calyx, and stamen, and other parts, each differing in look, texture, strength, and use from all the rest. The crystal is of the same material and appearance throughout: it is a mass which is equally dense, equally strong, equally colored in one part as in another—it is homogeneous; that is to say, its physical qualities are evenly distributed. The flower is easily seen to have organs, each of which has its own peculiar office; the crystal has no organs whatever. The one is organized—it has a structure; the other is not organized—it has no structure. Therefore we may study the anatomy of a flower, but there is no anatomy of a crystal for us to study.

Let us here draw a distinction between the words *organized* and *organic*. The first relates to anything which has organs—parts which are differentiated from each other; the second is applied to things which result from the vital activity of organized beings. Thus, caseine, which exists in milk and is the characteristic material in cheese, is organic, for it is a result of the activity of a living creature; but it is not organized, having no structure, one portion being exactly like every other. Many things—for example, water—are neither organized nor organic; they are inorganic.

All organized beings belong to one or the other of two great groups—plants and animals. The distinction may not be essential; indeed, there are creatures upon the dividing-line between these groups whose nature is not yet determined—perhaps they are plants, perhaps they are animals. But, although it may be impossible to give a definition which shall include all of either group without taking in some belonging to the other, these terms are not in the least likely to mislead us. The study of the structure of plants is called *vegetable anatomy*, and is thus distinguished from *animal anatomy*, which has to do with the organization of the members of the other group of creatures.

Physiology is often used, carelessly, synonymously with anatomy, but they are absolutely distinct. Anatomy is the science of structure; physiology is the science of function. Anatomy teaches us what organs a plant or animal has; physiology teaches us to what use these organs are put. Anatomy shows what

an organ is; physiology shows what an organ does. Anatomy may be, and usually is, studied upon the dead creature; physiology can be studied only upon the living—it requires organization in action.

Of all animals, the human was the first whose anatomy was studied with great care. Naturally, men were more interested to know what they could about their own bodies than about those of other creatures; and when they did investigate the structure of the members of lower orders, it was to be expected that they would institute comparisons between the organs of the latter and those in themselves which seemed to correspond. Thus it came about that they called the science of the structure of all other animals *comparative anatomy*, to distinguish it from the science of their own organizations, which is *human anatomy*. If they had begun their study of animal structure at the other end of the scale, taking first animals of the simplest organization and working up gradually through a series, each member of which was more elaborately constituted than its immediate predecessor, until they reached man, the term comparative anatomy would not be used in the sense in which it is generally employed. But, although we recognize the defects of their method, we must confess that in the same circumstances we would doubtless have done precisely as they did. Now-a-days, however, the student is counselled to begin with simple and easily understood structures, in order to prepare himself for the readier comprehension of the more complex, and finally of the most intricate. The study of the anatomy of the lower animals is an admirable—indeed, the best—preparation for that of human anatomy. One who is familiar with the structure of one animal in the great group in which man belongs, as the cat, for example, will find human anatomy immensely simplified. But comparative anatomy, as a separate branch, has no right to a place in the course of study in a medical school, and only occasionally and incidentally will it be referred to in this book.

Human anatomy is subdivided, according to the means employed in its study, into two great parts: *gross* or *macroscopic anatomy*, in which no aids to vision are employed, and *minute* or *microscopic anatomy*, in which the assistance of optical instruments is used.

According to the method pursued in its study gross anatomy is subdivided into *systematic* and *relational*. Systematic anatomy, called also *descriptive anatomy*, regards the body as made up of systems or sets of organs. For example, considering the human being from this point of view, we find that it has a nervous system (brain, spinal cord, nerves, etc.), a circulatory system (heart, blood-vessels, etc.), a digestive system (stomach, intestines, etc.), an osseous system (bones, etc.), a muscular system (muscles, etc.), a respiratory system (lungs, windpipe, etc.), an excretory system (kidneys, bladder, etc.), a reproductive system (ovaries, testicles, etc.). Knowledge of the various organs comprised in each of these systems is essential to the practitioner of medicine and surgery. But if he knows each of these systems only in a separate and unassociated way, he is far from being equipped anatomically as he ought to be. He still needs to learn how each part of every system is related to each part of every other system, and particularly what are the relations of each object to all of the other objects in its neighborhood or region. In other words, he must know his anatomy not only from the systematic point of view, but from the *relational*. Other names given to this method of study are *regional anatomy*, because by it the body is divided into regions for investigation; *topographical* (from the Greek word meaning "place"), a term used by civil engineers to designate a survey in which the position of every part of the territory involved is determined relatively to every other part; *surgical*, because operations cannot safely be performed without knowledge thus acquired; *medical*, because it is necessary to accurate diagnosis of disease of internal organs.

Systematic anatomy is made possible by *dissection*, by which is meant the careful and delicate cutting apart of the various structures, so that they can be observed and studied. It is practised upon the dead body. Much of relational

anatomy also can be acquired in this way; but a very modern method has revealed a multitude of facts in this connection which were previously unknown, and are incapable of demonstration by dissection alone. This new method is that of *plane sections.* The sections are made in the following manner: a body is frozen so hard that a saw, in cutting through it, encounters no more resistance in bone than in muscle. Cuts with a saw are made in any direction which one chooses, but the most common are the horizontal, the vertical sidewise (also called "coronal" or "frontal"), and the vertical fore-and-aft (known also as "sagittal"). The cut having been made, the saw-dust is very carefully cleared away from the surfaces, and the relations of the parts which have been brought to view are studied. As an elevation of temperature above the freezing-point will impair the fixity of the specimens, and as it is manifestly out of the question to maintain such a degree of cold permanently or to study the specimens comfortably during its continuance, it is usual to photograph them, or immerse them in a preservative fluid in flat vessels covered with plain glass, or to adopt both of these devices for continuing the study. Students are not expected to do this work, which involves great labor, skill, and, for interpretation of the appearances of the sections, a high degree of anatomical knowledge; but they can avail themselves of the results of this method by studying the actual sections or casts of them in their medical schools, or, what is sometimes better because more intelligible, pictures of sections made from photographs and labelled in detail.

Minute or *microscopic anatomy* deals with those features of structure which are too small to be recognized by the unaided eye. It can be studied only with the assistance of a microscope. A branch of microscopic anatomy is *histology* (the name coming from the Greek word for "texture"), which is the science of the tissues. But the name histology has been much used synonymously for microscopic anatomy, the whole getting its designation from a part, as in many other cases in our language. Histology is sometimes called *general anatomy,* because the tissues are distributed to all parts—are general to the various organs.

A homely illustration will serve to make the difference between these various subdivisions of anatomy clear. We may use the word "anatomy" with reference to artificial structures, as, for instance, the anatomy of a steam-engine or of a watch or of a house. Let us, then, regard a house from the points of view successively of the systematic anatomist, the topographic anatomist, and the histologist. The first of the trio considers the house as made up of sets of organs, a series of apartments devoted to alimentary purposes, as the kitchen and dining-room; another set used for sleeping—the bed-chambers; one for study—the library, and so on; a system of tubes conveying water to various parts of the establishment; another lot bearing illuminating gas to every room; a third supplying steam or hot air for raising the temperature; and still another carrying off liquid waste materials; large, vertical pipes by which injurious products of combustion are conducted away; a quantity of wires adapted to the conveyance of electricity for various purposes within the house, and a set of rods designed to keep electricity out of it. Thus he finds whatever organs go to compose a house, and describes each set by itself, so that a person who desires to know about any system of apparatus—as, for example, that used for heating or that for sewerage—can learn about it by consulting the record of the investigator's observations.

The topographic anatomist approaches the question of the structure of the house in an entirely different way. He examines the building by such means that, without actually cutting it into slices, he is able to make drawings which show just what these plane sections would display if they were made. He does not concern himself with any separate system of rooms or rods or pipes or wires, but he studies the relations which obtain between all of the objects which he sees in each of his imaginary sections. For example, he observes that the parlor is related to the cellar below, to a bed-chamber above, to a library behind,

to a corridor at one side, and a roofed piazza on two sides. He notes the electric wires, the gas- and steam- and water- and waste-pipes within the walls of the room, the chimney which projects into it, and the relations which these sustain to the room itself and to each other. He proceeds thus until every region of the house is investigated and mapped out, and when he has done all this one can get from his records a complete idea of the relations of every piece of the structure to every other.

Finally comes the histologist, who, disregarding systems of organs and heedless of the relations between various parts, looks only at the structural materials entering into the composition of the house; in other words, its tissues. He finds that the house is made up of stones, bricks, boards, beams, nails, slates, and many other things, which present to the eye definite forms by which they are recognizable. It may be that some one kind of these structural elements varies in shape and in other respects in different parts, as, for instance, the bricks, which are of one form, size, and smoothness in the outside wall, different in all of these respects in the inner wall, and unlike either of the other kinds in the fire-places; but they are all readily seen to belong in the same category.

Each of these three methods of considering the house has its uses; each alone is seen to be inadequate to convey a comprehensive idea of the building. An architect employs all of them: he is, as regards houses, a systematic anatomist, a relational anatomist, and a histologist; he knows what the organs of a building are, how they stand in space with reference to each other, and of what textures they are constructed. For exactly the same reason every practitioner of medicine must be a human anatomist in all three of these ways. He finds one disease affecting a given system—as, for example, the alimentary—and therefore has to know the organs of this system as a continuous series; he meets with another disease involving, not a set of physiologically associated organs, but a number of parts which are related to each other in a geographical way, occupying a limited region, and consequently he needs to be acquainted with the organs or parts of organs belonging to half a dozen different systems. In either case he may be unable to appreciate the condition of affairs if he is ignorant of the tissues entering into the composition of the structures which are invaded.

The body may be considered anatomically from still other points of view. If it is in a state of health, the study of its structure is *normal anatomy;* if it is in a condition of disease, *pathological* or *morbid anatomy.* When the organization is studied with especial reference to function, we pursue the method of *physiological anatomy.* The consideration of the plan or model upon which organs are formed constitutes *morphological anatomy;* and as the discussion of such matters is attended necessarily with more or less of speculation, the synonyms *philosophic* and *transcendental anatomy* are often employed. The object which the investigator has in view determines the division of the subject. Thus, if he studies the body with the purpose of representing it in a pictorial or plastic way, it is *artistic anatomy;* if his only intent is to acquire knowledge which will be especially serviceable in the practice of the healing art, it is *applied* or *clinical anatomy. Practical anatomy* is a name employed to indicate the study of the body by dissection.

It will be understood, however, that we confine ourselves to human anatomy solely; that we regard it only in its normal aspects; that, unless otherwise specified, the adult condition is assumed; and that we consider anatomy chiefly with a view to the interest which it must have for the student who desires to fit himself for the work of the medical profession. This will involve the study of systematic, relational, and microscopic anatomy, and in the treatment of many topics all three of these methods will go along hand in hand. Frequently the physiological anatomy will be presented at the opening of a section, because it is so much easier to understand a machine if we enter upon its study with a distinct idea of the work which it is capable of performing, than if we have no notion of its function.

The following tabulation will aid in recalling the principal points which have been made:

- Anatomy
  - Vegetable
  - Animal
    - Comparative (all lower animals)
    - Human (man)
      - Gross, or Macroscopic
        - Systematic, or Descriptive.
        - Relational, Topographic, or Regional.
      - Minute, or Microscopic (Histology)

NAMES AND DELIMITATIONS OF SURFACE PARTS.

At the outset of anatomical study it is important to have the clearest possible conception of the limits set by nature or by convention to the various parts which will be referred to constantly in the following pages, and also to have for each of these parts a name which shall be used for that and for nothing else. All parts, even the minutest, have technical names, which are Latin in form, and almost all parts which are visible without dissection, and those which are brought into view by accident, have, besides the scientific, vernacular appellations—names given by non-medical people who never had a thought of knowing anatomy. The scientific name of a part is understood in every land where medicine is cultivated; the vernacular designation in one language is generally different from that in every other, and frequently essentially so. Thus, what we call "head" in English is "tête" in French, "kopf" in German, "testa" in Italian; and the anatomist who is acquainted with no modern language but his own can understand only that one of these words which belongs to his native tongue. "Caput," however, means the same thing to English, French, German, and Italian, for all scientific men are supposed to know something of Latin, the language of scientific nomenclature. Only a small proportion of the names applicable to anatomical parts is included in the vocabulary of the common people, but anatomists generally use these in their writings; for the suggestion of pedantry which inevitably would come from the invariable employment of the technical terms instead of the existing vernacular words would be almost intolerably offensive. Unfortunately, however, quite a number of these vernacular titles are used by anatomists with different significations from those which they have to the unscientific; and hence it seems necessary to explain what meaning we shall attach to these words, which have been familiar to us from the cradle.

It may seem to some readers needless to undertake this enumeration and definition. But a large observation of medical students through many years has demonstrated that it is highly desirable to do exactly this thing. People of much more than ordinary intelligence and education rarely have any idea of the difference between the meaning which many a word has to medical men and that which is attached to it generally. When a surgeon hears through a non-medical source that a person has broken a leg or an arm, he simply gathers the impression that a fracture is supposed to have occurred in a lower limb in the one case and in an upper limb in the other case; but if leg or arm is mentioned by a medical man, he knows that the third segment of the lower extremity is meant in the first instance, and the second segment of the upper extremity in the second. "Wrist" to the laity means anywhere from the upper level of the palm to nearly halfway up the forearm; "hip" is used instead of "thigh," mention of the latter, for some inexplicable reason, being at present considered even more indelicate than that of "leg," for which polite usage has substituted "limb." These few selections from a considerable number will serve, it is hoped, to justify the attempt which is here made in the interest of precision of language and of thought.

In order to understand the application of the terms intended to designate the relation in space which different parts of the body sustain to each other, it is necessary to know what is regarded as the *anatomical position*. This is the erect attitude, with the palms of the hands turned to the front, and the soles of the feet horizontal—that is, facing downward.

To the anatomist "head" (*caput*) means all of the mass which is balanced

on the neck, the front and lower portions being "face" (*facies*), the upper and back "cranium," the dividing-line between the two parts starting at the so-called root of the nose in the mid-line, and extending on each side beneath the overhanging brows and downward and backward to the ear. But "head," in common parlance, means at some times all that we have included, as in decapitation; at others only the cranium, as in the use of the word headache. "Face" with the people embraces the anatomical face and also the anterior portion of the cranium: a beautiful face would be considered desecrated if its picture showed nothing above the eyeballs. And yet "face" is often used in a more restricted sense than the anatomical, as when one speaks of faceache, meaning pain in the cheek region only.

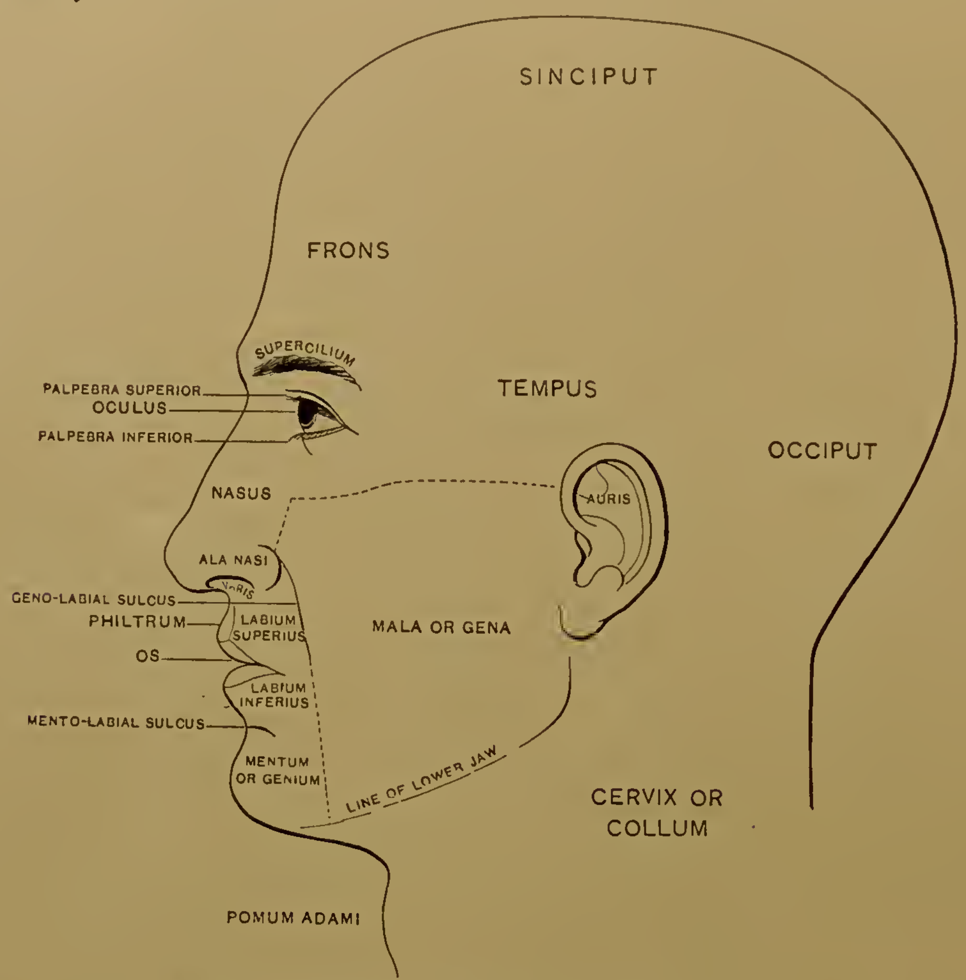


FIG. 1.—Side view of cranium and face. (F. H. G.)

The cranium is subdivided (Fig. 1) into an anterior part, the "forehead" (*frons*); an upper, the "crown" (*vertex* or *sinciput*); a back, the *occiput;* and, on each side, the temple (*tempus*). There are no surface-markings by which these are absolutely delimited. At the lower portion of the temporal region is the flaring part of the ear, known by anatomists to be the least important division of the organ of hearing (*auris*), but thought by people commonly to be about all of it, and consequently named "ear." The forehead terminates below at the "nose" (*nasus*) in the middle line, and on each side of this, in an arched border, usually covered with short, crisp hairs, and called the "brow" (*supercilium*). In the face immediately beneath each brow is an "eye" (*oculus*), that is, an eyeball or globe, shielded above by an "upper lid" (*palpebra superior*) and below by a "lower lid" (*palpebra inferior*), their edges fringed with short hairs, the "lashes" (*cilia*). Between the eyes and in the middle of the face, below their level, is the projecting part of the nose, which is all that is generally recognized as nose. This has on each side below an opening, presenting downward, the "nostril" (*naris*), guarded on the outer side by a flaring projection, the "wing of the nose" (*ala nasi*). What is commonly called the "bridge of the nose," a prominence caused by the nasal bones, has no technical designation. At a short distance beneath the nose is a transverse slit, to which, as well as to the cavity of which it is the opening, is given the name "mouth" (*os*). Above this aperture is the "upper

lip" (*labium superius*), and underneath it the "lower lip" (*labium inferius*). Popularly, the word mouth is often applied to the lips, as when a woman is said to have a pretty mouth—a comment which manifestly is not intended for the slit-like opening, and still less for the cavity behind it. (It may not be amiss to call attention to the fact that the Latin *os*, meaning a mouth, has *oris* for its genitive, and gives origin to our English oral; whereas *os*, meaning a bone, is *ossis* in the genitive, and thus stands behind our English osseous.) The upper lip extends vertically from the nose above to the free border below, and laterally to the crease which courses down and out from the hind border of the wing of the nose, and is called the *geno-labial sulcus;* the lower lip extends from its free edge above to a transverse crease, the *mento-labial sulcus*, which presents a downward concavity, and separates the lip from the chin. The middle portion of the upper lip projects farther downward than do the parts which bound it laterally, and its skin surface is marked by a somewhat triangular depression, the *philtrum*. The border of the skin of this lip describes a line which is a mark of beauty, and is called by artists the bow of Cupid. The "chin" (*mentum, genium*) is the central prominence which finishes the face below, in and near the mid-line. It is not distinctly separated from the cheeks. The main part of each lateral aspect of the face is the "cheek" (*mala, gena*), which presents a broad, quadrilateral expanse, bounded below by the inferior border of the lower jaw, behind by the vertical portion of the bone of this jaw, above by the lower margin of the orbit (the cavity lodging the eye) and by the ridge of bone running back from it, and in front above by the side of the nose, below this by the geno-labial sulcus and an imaginary line in continuation of this. The outlines of the lower part of the face are determined largely by its framework, the inferior jaw-bone (*mandibula*), which, with its various attachments and coverings, constitutes the under jaw (*maxilla inferior*). The upper jaw-bone is the staging upon which the greater part of the central zone of the face reposes. On separation of the lips the "teeth" (*dentes*) are seen projecting beyond the "gums" (*gingivæ*) in two arches with the convexities forward; and on depressing the lower jaw a view of the cavity of the mouth is obtained. In its floor we see the muscular "tongue" (*lingua*) with its rough upper surface; its roof is formed by the "hard palate" (*palatum durum*), and behind is the "soft palate" (*palatum molle*) hanging like a short curtain over the base of the tongue. Between the two upright ridges to which the soft palate extends on each side is the "tonsil" (*tonsilla, amygdala*), and beneath the pendulous veil of the palate we can see a part of the rear wall of a cavity for which the laity have no name, but which we know as the *pharynx*.

The "neck" (*cervix, collum*) connects the head and the trunk (Fig. 2). In front it extends from the level of the lower jaw to the "breast-bone" (*sternum*) in the middle line and the "collar-bone" (*clavicula*) on each side. These bones can readily be felt through the overlying structures. Behind, in the middle line, the neck extends from the base of the cranium to the seventh segment of the back-bone or spine, the tip of which can be both felt and seen projecting beyond the plane of any of its fellows above. Between this segment (*vertebra prominens*) and the collar-bones—that is, at the sides—there is no clear demarcation of the neck from the trunk when the upper limbs hang passively: there is usually an unbroken slope from the head to the peak of the shoulder. But if the shoulders are raised straight upward, a crease is produced which sharply indicates the boundaries of the neck for two-thirds or more of the distance, and suggests the line for the remainder. In this attitude of hunched shoulders the neck rises like a column from a depressed base. Although not exact in every respect, this technical delimitation of the neck is vastly more definite, as well as more restricted, than that which is in popular vogue concerning women arrayed in what is known as "full dress," whose necks, varying at different times according to the dictates of fashion, may find their lower limits anywhere between the collar-bones and the nipples in front, and between the vertebra prominens and

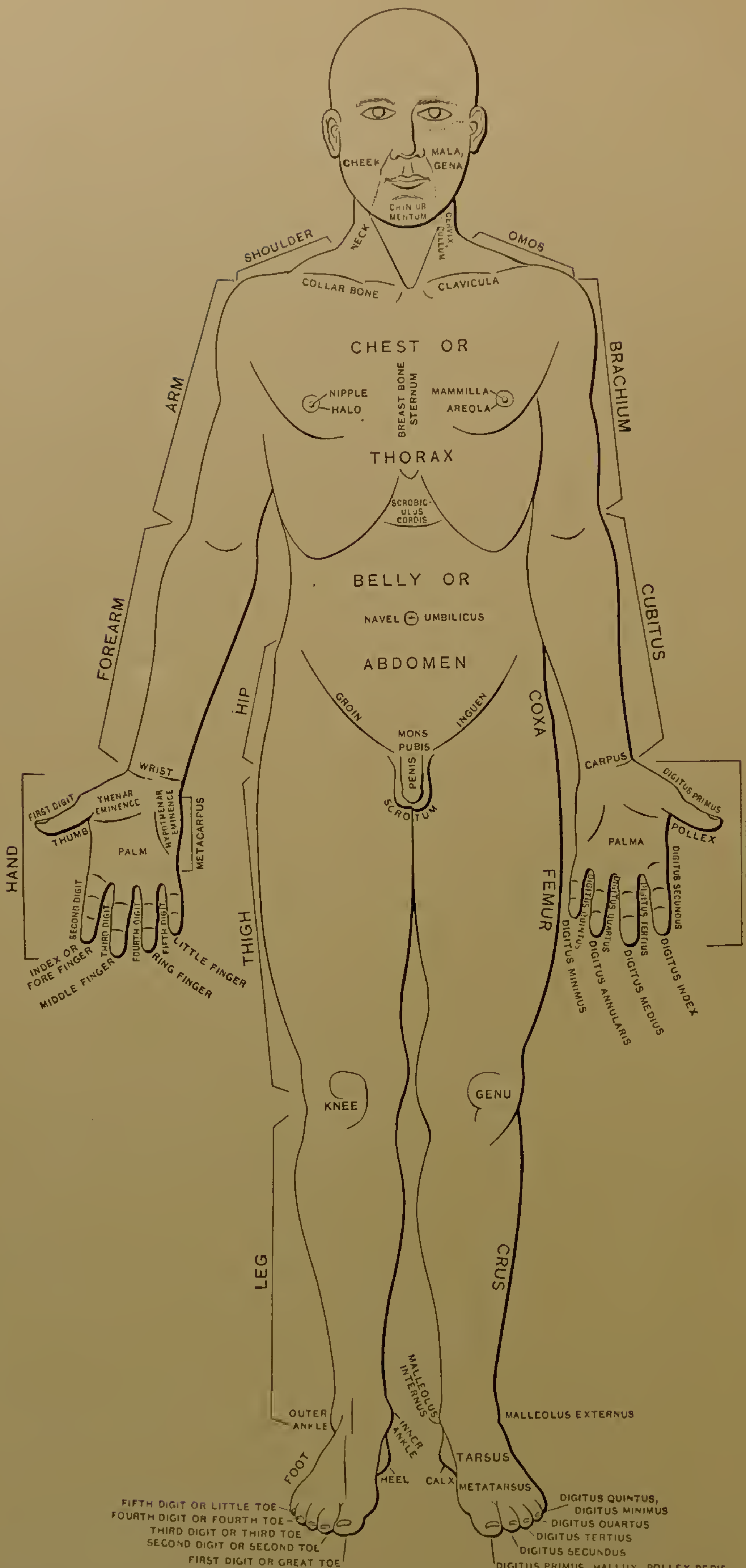


FIG. 2.—Front view of a man in the anatomical position. On one lateral half the parts are labelled in English, on the other in Latin. The right upper limb is drawn away from the trunk in order to show the arm more fully than is possible when it hangs perpendicularly. (F. H. G.)

the small of the back behind. The word "throat" has no anatomical equivalent. It is variously used to designate the front part of the neck, or the tonsils and adjacent parts of the soft palate, or the pharynx, or the organ of voice (*larynx*). High up on the neck in front is a hard protrusion, more prominent in men than in women, caused by the thyroid cartilage of the larynx, and called "Adam's apple" (*pomum Adami*) in playful celebration of the most noted and unfortunate gastronomic performance on record. The median portion of the neck behind is the "nape" (*nucha*). Just above the top of the breast-bone is often seen a little pit, esteemed a mark of beauty by artists, who have named it "Diana's pool."

The body proper, as distinguished from the entire organism, is known as the "trunk" (*truncus*), and presents two grand divisions, the upper of which is the "chest" (*thorax*), the lower the "belly" (*abdomen*). The superficial line of separation between them is pronounced, and is made by the bones and cartilages which form the lower border of the thoracic cage, as the skeleton of the upper cavity is called. Sloping downward and outward from the lower part of the breast-bone, the boundary-line is continued backward at the sides, and then obliquely upward behind. But this surface marking is by no means an indication of the relative size of the two cavities: it only shows the line along which is attached the base of a muscular dome, the *diaphragm* or midriff, whose central portion rises to the level of a point about halfway up the sternum, and shuts off the cavity of the thorax from that of the abdomen. Thus, the summit of the belly-cavity is rounded, presenting a marked convexity upward, and the base of the chest-cavity, into which the former rises, is correspondingly concaved.

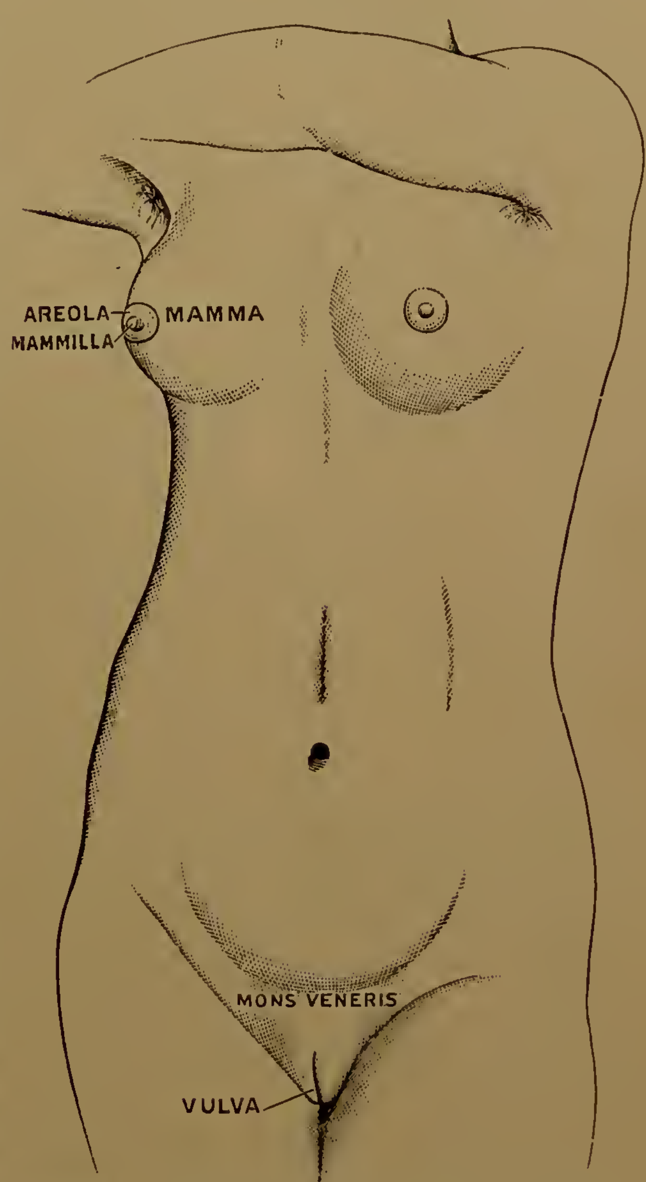


FIG. 3.—Front of torso of woman. (F. H. G.)

From the front of the chest of the adult female there projects a nearly hemispherical mass on each side (Fig. 3). This is the "breast" (*mamma*), the organ in which milk is formed. The valley between these hillocks is properly the "bosom," but this word is often used as synonymous with breast. At about the central point of each mamma stands out the nipple or teat (*mammilla*, literally "the little breast"), its base surrounded by a circular space which is distinguished by the darkness of its skin, and is called the *areola* (literally "the little area") or the "halo." The male has no milk-forming organ, but he has in the same relative situation upon the chest-wall slightly developed mammillæ, which indicate the position of rudimentary mammæ. These are good illustrations of a rule that the generative organs which are fully developed in one sex are aborted in the other, being represented in the latter by some little bulge or dimple, whose only use seems to be to suggest the narrow escape of its possessor from being of the opposite sex.

The belly at its upper central part presents a shallow depression, popularly called the "pit of the stomach," but technically *scrobiculus cordis*, which literally means "the little pit of the heart." This confusion of names arises from the physical (not the figurative) nearness of the heart and stomach, the one resting upon, the other lying underneath, the diaphragm, and both being in the region of this slight hollow. Farther down in the mid-line, and usually nearly on

a horizontal drawn between the highest points of the haunch-bones, is an irregular, puckered dimple, the "navel," called in Latin *umbilicus*, from *umbo*, the button in the centre of an ancient shield; so that we see that the childish name for the part—belly-button—has the sanction of a noble classical derivation. Following down in the middle line, we find at its lowest part an area which extends considerably sidewise, and is covered in the adult with crisp, curly hairs. This is the *pubes*. Behind the skin of the pubes the male has a little pad of fat, and the slight elevation which is thus produced is sometimes called *mons pubis*—that is, the mountain of the pubes. In the grown female there is so marked an accumulation of fat here as to make a very noticeable hillock, which is named *mons Veneris* (the mount of Venus), in honor of the Roman goddess of love.

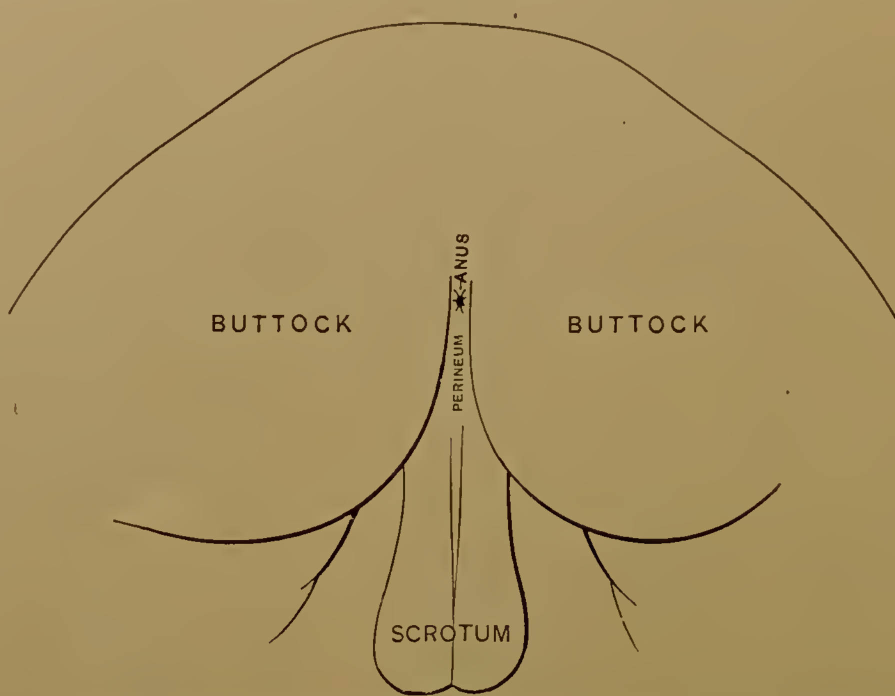


FIG. 4.—The male perineum and surrounding parts. (After His.)

Running obliquely upward and outward from the pubic region on each side is a crease which separates the trunk from the lower limb in front, and is called the "groin" (*inguen*). The name is usually applied to a narrow but indetermi-

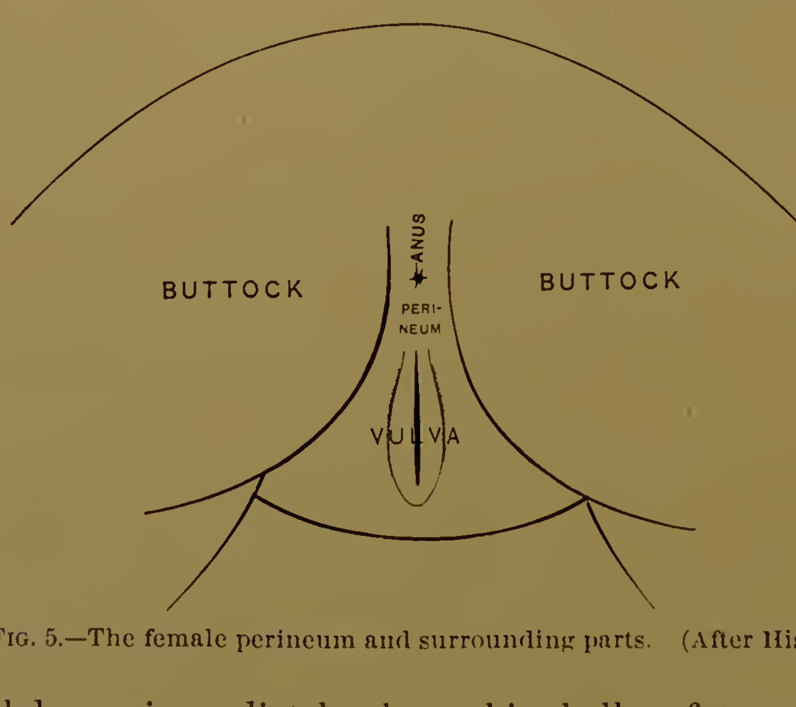


FIG. 5.—The female perineum and surrounding parts. (After His.)

nate area of the abdomen immediately above this shallow furrow, and the adjacent area of the thigh just below it.

Below the pubes are some of the generative organs—those which are superficially located, the external genitals (*genitalia externa*). In the male is the organ of copulation, whose technical title, *penis*, has practically displaced the entire

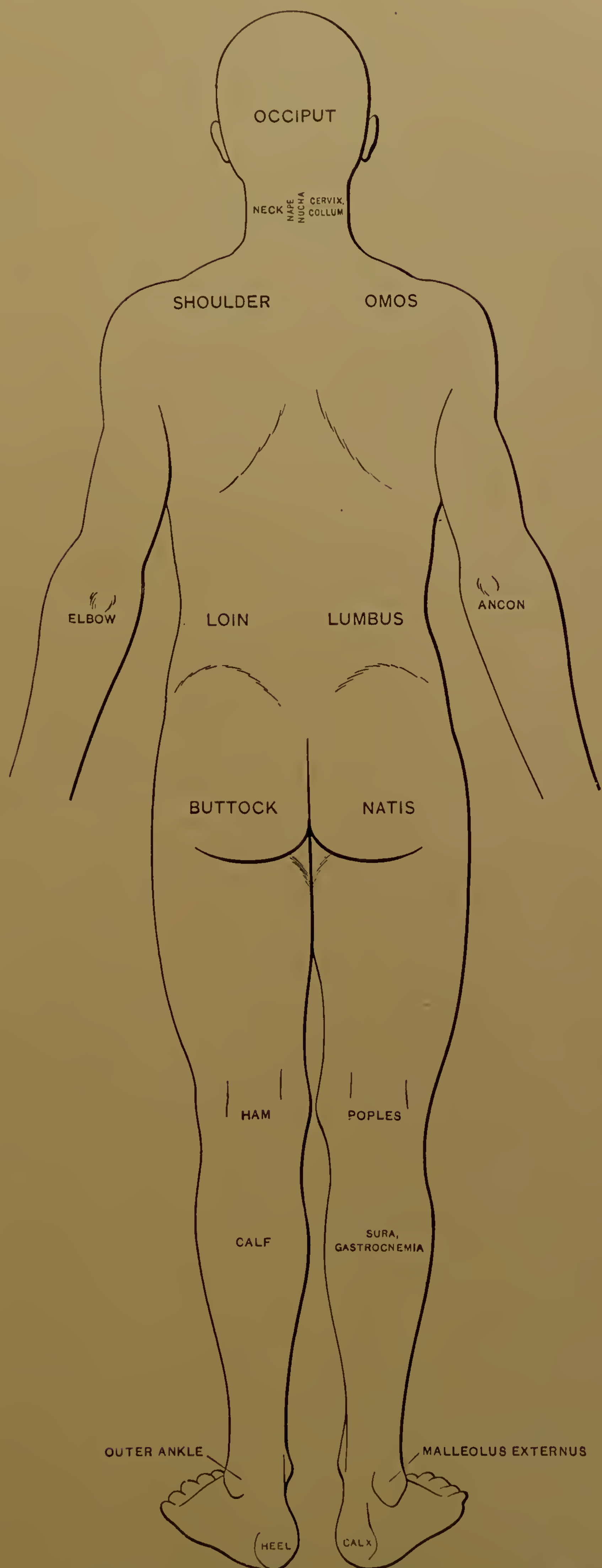


Fig. 6.—Back view of a man. On one lateral half the names of the parts are given in English, on the other in Latin. (F. H. G.)

group of Anglo-Saxon names by which it was formerly known. The free end of the penis, the "head," or *glans penis* (literally "the gland of the penis," from its resemblance to some internally located secreting glands), is covered by a long, movable fold of integument, the "foreskin," or "prepuce" (*preputium*). At the tip of the glans is a little slit, *meatus urinarius*, the termination of the common passage-way of the urine and semen. Behind the penis hangs the "bag" (*scrotum*) in which are suspended the essential male organs of generation, the two "balls" or "stones." which are more usually called by their Latin name *testes* (witnesses) or by the Anglicized diminutive of this word, "testicles." In the female the group of external genitals is designated by the name *vulva*, for which modern English dictionaries, with a fastidiousness not always imitated in popular speech, afford no single-word synonym. These structures are sometimes called *pudenda*, which means "things to be ashamed of"—as if such a criticism could justly be applied to the organs which are necessary for the perpetuation of the human race. The vulva presents a fore-and-aft cleft, which starts just below the pubes and runs backward between the thighs. This fissure is bounded laterally by thick folds of skin, *labia majora* (the greater lips), upon separation of which are seen the *clitoris* (which is the suppressed representative of the penis), two thin folds of membrane, *labia minora* (the smaller lips), the *meatus urinarius*, and the opening of the *vagina*, the tube which leads to the "womb" (*uterus*). Behind the external genitals of both sexes, between the thighs, and in front of the lower opening of the bowels is a narrow antero-posterior area called *perineum*, a word with no vernacular equivalent (Figs. 4 and 5). The rear limit of the perineum is marked by the outer opening of the *anus*, the terminal portion of the alimentary canal.

The posterior surface of the trunk (Fig. 6), generally called the "back" (*dorsum*), shows in the middle line from end to end a furrow in which appears a continuous series of bony prominences, each of which belongs to a separate segment of the pile of bones called the spinal column, or, naming the whole from a part, merely the spine or back-bone. Between the lower margin of the thoracic cage and the crest of the hip on each side, in the region known as the small of the back, is a "loin" (*lumbus*).

Projecting from the trunk are the "limbs" or "extremities" (*membra* or *extremitates*,) arranged in two pairs, an upper and a lower. Each pair has a bilateral symmetry, and therefore the statements which apply to one limb need not be repeated for its mate of the opposite side.

The "upper limb," "upper extremity," or "thoracic extremity" (*membrum superius, extremitas superior*, or *extremitas thoracica*) is divided naturally into four distinct segments. These, in regular order from above downward, are shoulder, arm, forearm, and hand. The "shoulder" (*omos*) connects the trunk and arm. The "arm" (*brachium*) extends between the shoulder- and elbow-joints. Beneath the shoulder-joint, and between the side of the chest and the arm, is a pyramidal space, with its base presenting downward, called the "arm-pit" (*axilla*). The "forearm" is known as *antebrachium*, which is the exact Latin equivalent of the English name, and also as *cubitus*, from which comes the name of a measure of length anciently employed. It includes all between the elbow- and wrist-joints. Its upper end is marked behind by a prominence, the "elbow" (*ancon*). The fourth and final segment of the upper limb is the "hand" (*manus*). This is subdivided into a proximal portion, the "wrist" (*carpus*), a central part, which constitutes the body of the hand, the *metacarpus* (meaning "beyond the carpus"), and a distal part, the "digits" (*digiti*). The front surface of the metacarpus is the "palm" (*palma*), and the hind surface is the "back" (*dorsum manus*). There are five digits to each hand, numerically named, beginning with that farthest from the median line of the body and counting inward. They have also other designations, which are used with equal or greater frequency. The first digit (*digitus primus*) is the "thumb" (*pollex*); the second (*digitus secundus*) is the "fore finger" (*digitus index*); the third (*digitus tertius*) is the "middle finger" (*digitus medius*); the fourth (*digitus quartus*)

is the "ring finger" (*digitus annularis*, from *annus*, "a ring"); and the fifth (*digitus quintus*) is the "little finger" (*digitus minimus*, literally "the least finger"). Each digit has three segments, except the thumb, which has but two.

The "lower limb," "lower extremity," or "pelvic extremity" (*membrum inferius, extremitas inferior*, or *extremitas pelvina*) is the homologue of the upper—that is, it is built on substantially the same structural plan.[1] It has four segments: hip, thigh, leg, and foot, which correspond respectively to shoulder, arm, forearm, and hand. Between hip and thigh is the hip-joint; between thigh and leg, the knee-joint; and between leg and foot, the ankle-joint. The "hip," or haunch (*coxa*), is so firmly united to the back-bone that it serves as a portion of the wall of the abdomen, the greater cavity of the trunk. Behind the hip and immediately below the loin is a large mass of muscle and fat, the "buttock" (*natis*). The "thigh" extends from the hip to the leg, and is technically called *femur*, which name is also applied to the single bone that forms its framework. The prominence in front at its lower end is the "knee" (*genu*), and the space opposite the knee on the posterior aspect is the "ham" (*poples*). The mistake of calling the buttocks the hams is often made, but has no justification. From knee-joint to ankle-joint is the "leg" (*crus*). Its rear bulge is the "calf" (*sura* or *gastrocnemia*, literally "the belly of the leg"), and the sharp vertical ridge in front is the "shin." At the lower end of the leg are two bony prominences, the "inner ankle" (*malleolus internus*) and the "outer ankle" (*malleolus externus*). *Malleolus* means "a little hammer." The "foot" (*pes*), like its homologue the hand, is divided into three parts—a hindmost, the *tarsus*, a middle, the *metatarsus*, and a foremost or distal, the "digits" (*digiti*). The "instep" of popular nomenclature has no equivalent in anatomical terminology, as it includes parts of both tarsus and metatarsus; and, on the other hand, there are no vernacular words corresponding to tarsus and metatarsus. The part of the tarsus which projects to the rear is the heel (*calx*); the top of the foot is its "back" (*dorsum pedis*); and the entire under surface is the "sole" (*planta*). The five digits are designated numerically, like their homologues in the hand, the count beginning, however, not at the outer end of the series, but at the inner—that nearer the median line of the body. Thus, the "toes" or digits of the foot (*digiti pedis*) are first, second, third, fourth, and fifth (*primus, secundus, tertius, quartus*, and *quintus*), respectively. But the first and last have other names also, the one being commonly called the "great toe" (*pollex pedis*, "the thumb of the foot," or *hallux*); and the other the "little toe" (*digitus minimus pedis*, literally "the smallest digit of the foot"). In giving the Latin names for the toes it is rarely necessary to employ *pedis* ("of the foot") to distinguish those of the lower extremity, as the context indicates which limb is concerned; and it is never essential to say *manus* ("of the hand"), as this is understood unless the contrary is obvious.

THE SYSTEMS OF ORGANS AND THEIR FUNCTIONS.

In studying anatomy the thoughtful learner is almost certain to conclude that he needs to know a great deal about every other part in order to comprehend fully the one which he has in hand. No organ, however simple, is independent: every one is so related to others, perhaps to many others, that they are absolutely essential to its life. In the same way it is true that some knowledge of many is necessary to the complete, or even sufficient, understanding of a single one. This fact constitutes a chief obstacle in the path of the anatomical student; but it may be diminished very considerably, and its residue rendered less discouraging, by his having presented to his mind at the beginning of his course a con-

[1] The difference between homology and analogy must be borne in mind. *Homology* relates to similarity of structure, *analogy* to likeness of function. The two do not always go together. For example, the upper limb of a man and that of a bird are homologous, because they are constructed on the same plan; but they are not analogous, because the one is used for prehension (grasping), and the other for locomotion (flying). The organization in the two cases is strikingly similar; the function is radically different. But compare the wing of a bird with that of a butterfly; both are devoted to the same use—namely, flying; but they are essentially different in structural plan, as can be seen on the most cursory inspection. Therefore they are analogous, but not homologous.

cise recital of the principal organs of the body and a statement of the chief function of each. In this way he will learn a number of most useful anatomical facts, and they will be grasped all the more readily because they are strung on a physiological thread. In the few succeeding pages an effort is made to afford the student just this assistance.

Organs Removing Waste Matters.

The human body is a machine, and, like every other machine, wears out in using. We all know that even in circumstances favorable for the preservation of a corpse, such as coolness and dryness of the atmosphere, it undergoes destructive changes so rapidly that before many days have passed what was once an object of beauty and the occasion of delighted admiration becomes altogether grewsome and revolting. And yet, swift as is this putrefaction, the wearing out of the tissues in life is more speedy. The greater the physical activity of a man, the more rapidly are his textures broken down. Every movement, however trifling, every glance of the eye, every thrill of sensation, every thought or emotion, is attended with destruction of substance. The products of this waste are poisonous, and if retained in the system in any considerable amount cause sickness and even death. But there are channels by which these effete and toxic materials are continually escaping—namely, the *lungs*, the *skin*, the *kidneys*, and the *bowels*. Water, the common vehicle in the body-changes, carries them out in solution. The solvent and vehicular services of water are very manifest in the case of the urine, which is loaded with the waste escaping through the kidneys; and they are often as plain in the case of the perspiration, which contains the effete matters discharged through the skin. The excrement which comes from the bowels is not in solution when it appears, but this is due to its loss of water subsequently to its formation and during its detention in the intestine. Other products of decomposition are borne out with every expired breath, this being saturated with water, as appears by its visible condensation whenever the surrounding air is sufficiently cooled.

The Vascular System.

At this point there naturally arises the question of the means by which the various effete materials that are constantly being formed in every part of the body get to the four outlets named. This carriage is accomplished by the vascular system, which consists, first, of a complicated series of tubes, the *blood-vessels*, connected with which is a powerful organ, the *heart*, which drives the blood in a continuous current through them; and, second, of another set of tubes, the *lymph-vessels*, whose stream of lymph flows into that of the blood. Almost everywhere in the body there are minute crevices between the elementary particles and threads of the tissues, and into these chinks the textures discharge their wasted molecules, always in solution in water. These tissue-crannies communicate with little cylindrical tubes, into which the liquefied waste is poured. The tubes are lymph-vessels, and they conduct their contents to certain blood-vessels, where it mingles with the current of blood. Some effete matters pass from the tissues directly into the blood. The blood is contained in and completely fills the heart and the blood-vessels associated with it, these being, first, the arteries, which are tubes through which the blood flows from the heart *to* the tissues; second, capillaries, microscopic tubes of wonderful thinness and delicacy, through which the blood flows *in the midst of* the tissues; and, third, veins, through which the blood flows *away from* the tissues. The heart, which is a kind of force-pump, drives the blood through this great system of tubes in a ceaseless stream, and thus brings it in practical contact with the tissue-elements that make up the various organs. When the blood, laden with impure matters from every part of the body, comes to one of the organs (kidneys, lungs, bowels,

or skin) which is capable of withdrawing decomposition-products from it, the particular poison which this organ can abstract is removed, and the blood is by just so much rendered less impure. Coming to another one of them, it gets rid of the foul material which can be unloaded at this door of exit; and so on at the others. The lungs are sewers for certain excrementitious substances, the kidneys for others, the skin for a third group, and the intestines for the remainder. In this way are eliminated all of the materials which result from the constant wearing out of the body.

Organs Supplying Nourishment.

If there were no compensation for the destructive changes which are going on incessantly, in a very short time every life would cease. But just in proportion to the extent of the waste, and practically simultaneously with it, repair takes place. As an old particle lapses from a tissue a new one supplies its place without delay, even as the ranks of an army, though constantly suffering from the ravages of disease, death, and desertion, are kept full by the enrolment of fresh recruits. The portals of the body by which the new materials are introduced are the respiratory and the alimentary organs.

First of all in importance is the *respiratory system*, which embraces the nasal passages, the pharynx, the larynx, the windpipe, the bronchi, the bronchial tubes, and the lungs, the last being the essential parts. But some critic observes immediately that the lungs have been mentioned already as channels of elimination. Very true, but they are also channels of appropriation. Not only do they expel vile and injurious waste matters with every outgoing breath, but they admit to the blood pure and sustaining nutrient material with every incoming breath. Here is one of the economics of nature—the wagon is never empty: it carries out the offal and it returns with a load of food. Second, we have the *alimentary tube*, with its attendant organs, the *salivary glands*, the *pancreas*, and the *liver*. This tube is very long, including the mouth, part of the pharynx, the gullet, the stomach, the small and the large intestines, the last mentioned having, like the lungs, the double and contrary functions of appropriation and excretion. It is furnished with apparatus by which solid food can be chopped, crushed, moistened, and reduced to a pulp, and other contrivances which dissolve and change the food in various ways until it is in such condition that it can pass through the walls of the tube and enter the capillary blood-vessels and lymph-vessels, which form fine networks in the substance of its walls. Passing into these two sets of vessels by the process of absorption, some of it reaches the blood immediately, and the remainder somewhat indirectly by way of the lymphatics. The blood, therefore, is seen to be enriched by gaseous material in the lungs and by liquids and liquefied solids in the alimentary tube. All of these additions are brought by the veins to the heart, and thence are pumped into the arteries. The latter pour their contents into the capillaries, which are embedded in the tissues. These minute vessels are so thin that the nutrient substances in the blood can pass through their delicate wall, come into direct contact with the tissues, and flood them with food. To each tissue is offered a repast substantially identical with that furnished to every other, but no two of them choose the same articles from this sumptuous table, each having a selective capacity for those things which are best adapted to the preservation of its own peculiar characteristics. So, each tissue having appropriated whatever it needs, the residue of the nutrient material is carried away by the lymphatics along with the waste products already mentioned. It will be observed that it is the vascular system which takes supplies to the tissues, and the same system which carries from them the products of waste.

In connection with the alimentary tube were mentioned, as accessory parts, the salivary glands, the pancreas, and the liver. These are true glands—that is, organs which abstract certain materials from the blood, manufacture them into

new substances, and discharge these last into cavities or upon surfaces. The salivary glands empty their products into the mouth; the pancreas and the liver pour theirs into the small intestine; and these fluids—saliva, pancreatic juice, and bile—effect certain digestive changes in the food.

Organs of Internal Secretion.

There are other organs which resemble true glands in their general gross appearance, but are unlike them in an important respect: they have no tubes through which their products can be discharged upon a surface or into a cavity, and hence they are called ductless glands. They are the spleen, the thyroid body, the thymus, the suprarenal capsules, the hypophysis, the parathyroids, and the carotid and coccygeal glands. It is supposed that they furnish substances which produce a profound impression upon nutrition, and that these matters, as soon as formed, are thrown into the blood, whence the material for their formation was originally derived.

Organs of Motion.

Certain organs are devoted to the work of movement. Through their instrumentality man is enabled to seize and retain his food, to defend himself from and to assail his enemies, to move about from place to place, and to do numberless other acts in which motion is the principal factor. The organs giving man such power are *muscles.* They form the most of the bulk of the limbs and a great part of the walls of the cavities of the trunk. The lean meat of animals, which is a part of our food, is muscular tissue.

Framework Organs.

All of the organs of the body are held in suitably close relation to each other, and are yet kept from crowding together with injurious force, by certain structures which are called skeletal. The most striking and familiar of these are the bones, which form a stable framework for the various parts, a strong protective wall for cavities containing organs of great delicacy, and powerful levers upon which the muscles act. Cartilages are usually closely associated with bones, but there are cases in which cartilages by themselves perform just such services as bones more commonly do. However conspicuous these hard structures may be in their peculiar line of work, it is doubtful if they are of more use in the animal economy, even in their peculiar province, than are certain soft, flexible tissues. The fibrous tissues do almost all of the minute detail of support, the bones and cartilages being devoted only to the coarser kinds. All through the organs is a fine network of these tissues, furnishing a veritable skeleton for the microscopic elements of which the organs essentially consist. There are also substances which serve as stuffing and cushion-material for various parts.

Organs of Relation.

Of all the organs, those constituting the nervous system are the most exquisite in structure and the highest in function. They are the *brain,* the *spinal cord,* numerous small collections of nervous tissue called *ganglia,* and a great number of cords, the *nerves,* each of which has a connection at one end with some one of the nervous masses above mentioned. The nervous system gets its proper share of attention from the other organs which have been spoken of as engaged in carrying off waste, furnishing material for repair, moving parts or the whole of the body, and doing the passive service of framework. But it acts as if it recognized the great obligation resting on nobility, and it returns the devotion of its humbler neighbors by services of the most exalted order. It regulates and harmonizes the operations of all of the other parts, keeping them up to their work, restraining them if a tendency to overdoing appears, sustaining the equilibrium of all the functions. But, in

addition to all this, it brings the individual into conscious relation with the world around him through the medium of the organs of special sense. Without this last service our lives would be purely vegetative.

Organs of Reproduction.

The functions of the organs thus far mentioned concern only the individual, providing, first, for his preservation, and, second, for his relation to the things around him. There are other organs—not, however, in a condition of functional activity during the whole of life—which are necessary to the preservation of the race. These are the organs of generation. One series of them is present in the female, and its chief members are the *ovaries*, which furnish eggs; the *Fallopian tubes*, by which the eggs are conducted to the womb (uterus); the *womb* itself, in which the eggs, if fertilized, may remain during the period of pregnancy; the *vagina*, which receives the penis of the male in copulation and gives passage to the young when the time for its birth has arrived; and the *mammæ*, from which the progeny obtain sustenance for a considerable period. The other set of organs belongs to the male, and its principal parts are the *testicles*, which furnish the essential part of the semen for the impregnation of the eggs; certain *tubes* by which the semen flows to the *urethra*, the conduit common to the urine and the generative fluid; and, finally, the *penis*, the member by which sexual connection is effected and the male product deposited in the female generative passages.

THE ORDER OF TOPICS.

The chapters in this book are arranged substantially in the conventional order. First comes a brief presentation of the elementary tissues, followed immediately by a chapter on embryology. Then succeeds the descriptive anatomy, in which the organs are treated in systems, and after this the topographical, which deals with the relations of the different organs to each other.

That the account of the histologic materials composing the various organs should precede the description of these structures, and that the mutual relations of the latter should not be presented until the organs themselves have been described, are so logically necessary as to require no explanation. But the succession of topics in the systematic anatomy should be made to vary according to circumstances.

If the learner is studying anatomy only, the arrangement set forth in the table of contents is useful. But if he is studying physiology at the same time, he would do well so to modify the order that he may obtain a knowledge of the structure of each organ just before its function is considered. As physiology is concerned largely with the contents of the cavities of the body, this plan will involve the study of the viscera, including the brain and cord, early in the course. Any hours which are fairly due to anatomy and are not consumed in this preparation for the profitable study of functions should be devoted to osteology, and after this has been mastered the topics would best be taken up in the order as stated—joints, muscles, fasciæ, vessels, and nerves.

METHODS OF STUDY.

Any work which is done according to a prearranged system is more economical of time and effort and more productive of desirable results than that which is done in an unmethodical way. It is particularly important for the student of anatomy to follow lines wisely laid down for his guidance, because of the limited time at his disposal in which to acquire a mastery of the multitude of facts needful for his subsequent progress. Some words of counsel, therefore, are here offered as to the methods of study which experience has shown to be advantageous.

Merely reading the text-book is productive of but little good. Many a man who has done this faithfully is utterly unable to answer a question which would be likely to be included in the list prepared by any competent board of examiners. The facts are so numerous, and often so seemingly unrelated to each other, the names of objects are so unlike anything previously known, and the allusions are so frequent to matters which must remain unexplained until a later part of the course, that it is wellnigh impossible to bring away from a single reading, however careful, much more than a chaotic impression of the subjects considered. Some students in their desperation resort to the plan of verbal memorizing—learning word for word the descriptions in the book. It is hard to conceive of a method more wasteful of energy and less fruitful of results. One who has done this may be able to pass a brilliant oral or written examination, but he has not begun to be an anatomist; he is helpless in the presence of the dissected subject, and incapable of using what he has studied in any practical way. A student should not allow himself to adopt this method. He must learn the facts in such a way that a permanent image of every object is produced in his mind, and thus his knowledge will be available at the bedside. Of course it is necessary to acquire a nomenclature—to learn the names of the objects dealt with—for without these labels of things it is impracticable to receive information, to retain it easily, or to impart it after it has been gained. But this is a vastly different thing from committing to memory the precise phraseology in which any author, however learned and eloquent, has framed his presentation of the facts. The clearer and more forcible a statement in the book, the better is it for the student; but, the idea having been grasped, its clothing of words should be ignored. The student should be satisfied with nothing less than such a comprehension of the fact that he can lucidly convey it in his own language to one who never heard of it before.

It is generally very advantageous for the student to have before him the object while he is reading the description of it, for thus he is able to verify or correct the account which is given, and to get more concrete and enduring ideas of the various qualities of the thing itself. When osteology is under consideration, it is not difficult to pursue this ideal course; for even if the student cannot afford to buy a complete articulated skeleton, he can obtain by a small expenditure a sufficient number of separate bones to supply almost all of his needs. The little outlay required for this purpose will be more than justified by the returns, however impecunious he may be.

Many of the organs cannot be preserved in such condition that they can be studied to advantage in any such way as can the bones; but as substitutes for them we have casts and models—the former representing exactly the external form, size, and color of the originals, the latter in many cases doing this and also showing some details of internal structure. Both casts and models may be more instructive to the beginner than the objects for which they stand, even supposing the latter to be entirely normal, inasmuch as the real specimens are generally so soft and flabby that they do not retain their shape as do their artificial representatives, which are made of rigid materials and possess the additional merit of comparative indestructibility and can be used year after year without appreciable diminution of value. When minute parts are in question models are far preferable to the real objects, as they are of colossal size. The pigmy organ tells its story in a tiny voice which we cannot understand unaided; the giant model shouts its message in tones which a whole roomful of people can hear.

But even casts and models are usually not available except in medical schools, and we are consequently driven to employ pictures, which, fortunately, are to be had in such abundance and of so admirable quality that we often hardly miss the the really ideal means of illustration. Every one learns more quickly from a good pictorial representation than from the best description, for the mind stores up the impressions of form and color which enter it by the channel of sight far more eagerly and tenaciously than it does those which reach it by way of spoken

words. Where the subject is very complex, a diagram is commonly more useful than the best pictorial representation, because it eliminates everything but the essence of the matter, and thus does not confuse the mind by too vast an array of facts. The student, however, should scrupulously avoid allowing himself to be content with a merely diagrammatic knowledge of any part of anatomy: he should use the schematic picture only as a prelude to the actual thing, as the map which informs him where and how to find and learn about the unknown land and its contents.

Although descriptions, diagrams, pictures, models, and casts have their distinct value, each in its peculiar field, it must never be forgotten that after learning all which they can teach it is of the greatest importance to have contact with the natural object. Dissection of the dead body supplements and rounds out the knowledge which has been previously gained, and its service is indispensable. It is not well to attempt dissection until one has learned by other means the principal facts about the part to be dissected, because without such antecedent knowledge material, which in most places is scarce and costly, will be wasted by unintelligent cutting. But after the student has qualified himself to appreciate the views which can be obtained only in the anatomical laboratory, he should embrace every opportunity to dissect, for thus only can he become a practical anatomist. When a human body cannot be procured for this work, the manual dexterity which is so important an accomplishment for a surgeon may be cultivated by the dissection of cats, dogs, and other animals, which are abundant and cheap; and this practice is a most desirable preparation for the study of human anatomy for other reasons than the mere skill in the use of some instruments which it bestows.

Among the aids to the acquisition of anatomical knowledge, two which are but little appreciated deserve especial mention.

The first of these is the recitation. In this exercise the student is obliged to describe the things which he has been studying. This is a severe but most wholesome test of his knowledge. By it his attention is attracted as in no other way to the defects of his attainments. Some matters which he had flattered himself were perfectly understood are found to have been only partially learned, and in others he discovers that he has acquired mistaken notions. The ability to describe a thing clearly and fully to others is a convincing evidence of attainment, and the exercise of it is a capital method of fastening the truth in the mind. If possible, the student should associate with himself another of the same class, and no day should be allowed to pass without a serious, exacting quiz, the two alternating in the office of questioner.

Valuable as are the quiz and recitation in correcting and increasing one's knowledge, they are almost equalled in these respects by drawing. Sight and touch give an excellent idea of the form of a bone, but the information gained by these means is greatly intensified by making a free-hand picture of it; and in the process one is almost sure to see features which were not previously appreciated, and to rectify some faulty opinions. The same is true of all other objects, and the student is earnestly advised to make a drawing of every one of his dissections. If the natural objects are not available, he should draw the casts and models which he has the privilege of studying, and, in default of better representations, even the pictures in his text-book.

But the objection is at once raised that only a few peculiarly gifted persons are capable of drawing. It is not uncommon to hear men declare that they cannot learn to draw. This statement, however, is absurdly incorrect, for every such objector can already write, and writing is nothing but the drawing of certain arbitrary characters. One who makes a capital A can surely outline a tent; if he can make an S, he can draw a wriggling snake; in forming an X he has pictured a St. Andrew's cross; and thus every one who signs his name demonstrates his ability to draw. The talent is undoubtedly more marked in some persons than in others, but is possessed in some degree by all; and, however

slight it may be originally, it can be cultivated to such an extent as to be wonderfully serviceable to the medical student.

Although the few succeeding paragraphs are not specifically anatomical in their bearings, they have a pertinency in this place because every medical student at the beginning of his career should be given the advice which they carry and which he is unlikely to find elsewhere.

Among the articles of equipment which a medical student needs none is more important than a good medical dictionary. It is an indispensable. If he ignores its aid, he is doomed to stumble and blunder in every direction; if he accepts the assistance which it will give for the asking, he can progress readily and vigorously in all the paths of medical study.

A medical dictionary, in order to be thoroughly serviceable, ought to possess the following characteristics: The inclusion of substantially all of the words employed by the English-writing medical authors of the time; the arrangement of these words in alphabetical order; the various accredited spellings of the words; the pronunciation of those words on whose orthoëpy one might go astray; the etymon or original form of each, and the simplest translation of it; and a concise definition of the word in each signification in which it is employed. Several lexicons constructed on these lines are available, any one of which will do good service; but one which is less ample will not satisfy the reasonable requirements of the student.

Although the so-called Roman pronunciation of Latin is generally taught in the schools and colleges of this country, the dictionaries, for sufficient reasons, use the English pronunciation of the Latin and Latinized words which form the principal part of the vocabulary of medicine; and this method is recommended to the student for his adoption.

The student is earnestly advised to establish the habit of consulting his dictionary whenever he encounters a word whose meaning he does not know. He should fix the spelling in mind, learn the definition, observe and remember the derivation, and repeat the proper pronunciation until the tongue has fully mastered it. Finally, he will do well to ascertain the kinship of the word, if any exists, to other words already known, and to group these all together in his memory as relatives. By this method he will rapidly acquire a large vocabulary, the ability to employ words with strict regard to their meaning, to spell correctly, to pronounce elegantly, and, as an accompaniment and result of this training, he will be content with nothing less than precision of thought.

ELEMENTARY TISSUES,

AND THE STRUCTURE OF MEMBRANES AND GLANDS.

By F. H. GERRISH.

A FULL presentation of microscopic anatomy would require a large volume. It is the main purpose of this chapter merely to give a brief description of the elementary tissues which enter into the formation of the body. Without a knowledge of these primary textures much that must be said of the gross anatomy of different parts will be unintelligible; indeed, it is impossible to understand any organ, either from the anatomical or physiological point of view, unless the materials of which it is composed and the various physical properties of these substances are known with perfect familiarity; for the tissues are to the organs as the letters of the alphabet are to written words.

The minute structure of the viscera will be described in connection with the macroscopic features of each organ in turn.

CELLS.

The word "tissue" means, in ordinary parlance, a web-like structure or a woven fabric. Anatomically, it is applied to any organized substance in the body. Notice that in this definition the word "organized" is used, not "organic." The latter would, indeed, exclude the substances which are inorganic—that is, all of the ultimate elements, of which there are many in the body—leaving them to the consideration of the chemist; but it would include quite a number of substances found in the body which, although organic, have no title to be called structures, and belong in the domain of the physiologist, who deals with the proximate principles. Thus, albumin and fibrin are organic substances, but not organized; and, consequently, they are not tissues, for tissues are always organized.

Every tissue originally consists of microscopic particles, named "cells," which have been aptly called the simplest expression of tissue. Etymologically, the word "cell" is an unfortunate designation, based upon a mistaken belief as to the structure of the corpuscle. At first it was thought that cells were cysts, sacs, vesicles, with fluid contents. But it was long ago learned that they are usually solid bodies, and hence a word which implies the existence of a cavity, as does "cell" (Latin, *cella*, "a small, hollow cavity"), is a misnomer in the majority of cases. However, the substitutes proposed have not met with general favor, and "cell" has become so firmly fixed in our nomenclature that we shall not attempt to displace it; indeed, there is no call to do so, since no confusion need arise from its use in this arbitrary sense.

Not only is it true that all of the tissues primarily are composed of cells, but, going back much farther than this, we recognize the origin of the entire body from a single cell, the ovum (egg). This enforces the saying, which has become almost an axiom, that every cell comes from a pre-existing cell.

Of the numerous definitions of cells, that which seems most exact is the *ultimate morphological elements of the tissues*. It is not sufficient to say that they are the "ultimate elements" of the tissues, because that term refers to their chemical constituents: it is necessary that the definition should include a word which explains that the elements referred to have a definite, distinguishable, and characteristic shape, and this requirement is fulfilled by the word "morphological," the adjective from "morphology," the science of form. Thus is conveyed the idea that in histological analysis—which is to the microscopic structures what dissection is to the macroscopic—we do not go beyond the cell; that this is the last thing reached by the process; and that in all of the textures it has such definiteness of form as to enable us to differentiate one tissue from another.

FIG. 7.—Diagram of a cell. (F. H. G.)

The typical cell (Fig. 7), capable of development and reproduction, is a round or ovoid mass of protoplasm in which is a nucleus.

Protoplasm (from Greek words meaning "the first" and "the thing formed") is a substance whose properties underlie the vital functions, and therefore it has been called the physical basis of life. It is homogeneous, soft, and jelly-like, and possesses contractility—the power of shortening a diameter, of drawing one of its parts nearer to another. It usually looks granular, but this appearance will be explained a little later.

The *nucleus* is a roundish mass, generally central in location, and named from the Latin word which means "the kernel," because its situation is so suggestive of the meat of a nut. Sometimes the nucleus contains a small body (perhaps more than one) bearing to it a relation similar to that which the nucleus itself sustains to the cell; and this is called the *nucleolus* ("the little kernel").

The typical cell has no investing membrane. The granular appearance of its protoplasm is due to a network (*spongioplasm*) which becomes visible with lenses of high power. In the meshes of this plexus is a nearly fluid, homogeneous material (*hyaloplasm*). The nucleus has a similar construction, but has additionally a limiting membrane. The nucleoli are connected with the reticulum (network) of the nucleus. One point on the nucleus is called its pole, and the exactly opposite point is its antipole.

The protoplasm may become condensed at the surface, and this hardened peripheral part is called the cell-wall. A deposit of chemical substances in the wall frequently occurs, and contributes to its solidity. Cells may produce material superficially in large amounts without essential change of their own shape; and thus are formed substances called intercellular ("between the cells"). Tissues consist of cells and intercellular substance. In shape cells differ widely: the various forms will be described in connection with the discussion of the respective textures. Some cells are less than $\frac{1}{2500}$ inch in diameter, others more than $\frac{1}{200}$, and between these extremes are all possible gradations.

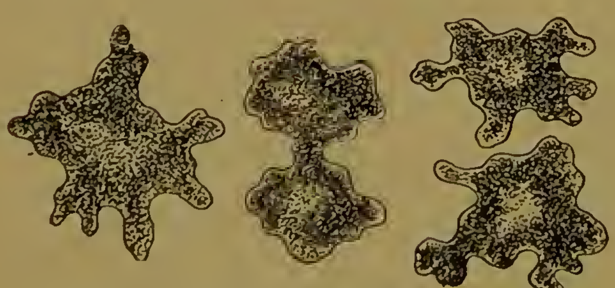


FIG. 8.—Amœboid movements. (Häekel.)

As has been said, the protoplasm of the cell possesses contractility, and this property enables it to display movements which are known as amœboid, because they are observed in a typical form in a unicellular, aquatic creature called *amœba*. In its amœboid movements (Fig. 8) the cell alters its form rapidly, assuming indescribably fantastic outlines, due to the irregular contraction, first, of one portion of the mass, and then of another part. By virtue of this quality the cell can move from place to place, one point becoming fastened, and the rest of the cell moving up to it and pushing out a process to a farther point in the same

direction. Thus is accounted for the migration of cells from blood-vessels, and their wandering from one point to another outside of the vessels.

CELL REPRODUCTION.

The formation of new cells is accomplished by division of old cells. The direct method, by which every element of a cell was equally divided by a transverse constriction, was formerly supposed to obtain generally, but is now known to be very rare. The indirect plan of division is almost, if not quite, universal. By this method the nucleus undergoes a series of complicated modifications, which, taken as a whole, are called *karyokinesis*, a name derived from the Greek words for "nut" and "change," the signification of the compound being "the changes in the kernel" or nucleus. In studying the details it is well to bear in mind that in this process, which is the principal movement toward the creation of two cells out of one, there occurs such a division of the cell-protoplasm and of the nucleus that each of the new-born cells inherits a half of every portion of the parent-cell's estate.

When division is about to take place the nucleus noticeably enlarges (Fig. 9). The nuclear membrane and the nucleoli disappear, and the secondary filaments of the reticulum are drawn into the primary threads, making them thicker and more conspicuous (Fig. 10). It is not positively determined whether these threads

FIG. 9.—Nucleus enlarged. The body of the cell is represented merely in outline in this series of diagrams. (F. H. G.)

FIG. 10.—Nucleoli and secondary filaments have disappeared. (F. H. G.)

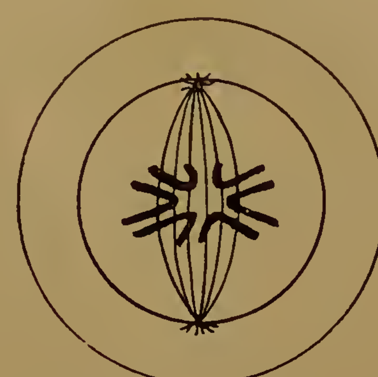


FIG. 11.—The spindle and V loops, side view. (F. H. G.)

all unite and make one, or are separate; whichever is true, they form a peculiar and complicated tangle which is called the *skein*. The diagram does not attempt to display all of the tortuosities of the skein, as they are rather confusing. There now appears a skeleton *spindle* (Fig. 11), formed of delicate filaments of the interstitial substance, placed with one extremity at the pole and the other at the antipole. At each end of the spindle fibrils of the protoplasmic network converge and produce the appearance of rays. At the next step (Fig. 12) a number of

FIG. 12.—V loops, end view. (F. H. G.)

FIG. 13.—Daughter loops, end view. (F. H. G.)

V-shaped loops are observed in place of the skein, these resulting either from the breaking of the single thread, on the one theory, or, on the other, from the plainer manifestation of the always separate threads. These V-shaped pieces are short and thick, and marshal themselves around the equator of the spindle, with apices to the centre and limbs outward, producing a star-like appearance, which is

sometimes called the *wreath*. Simultaneously with this movement the loops are split lengthwise (Fig. 13), so that each original (or mother) loop is made into a pair of secondary (or daughter) loops—a most important part of the series of changes. Next, the twin sisters in each V-shaped loop turn away from each other, one moving her head toward the pole, the other toward the antipole, their limbs being interlocked (Fig. 14). Presently they separate entirely, and migrate to pole and antipole respectively, travelling along the lines of the spindle, which seem to serve as guides to their movements. Arrived at their destination, each

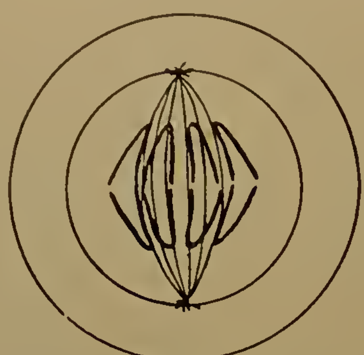


Fig. 14.—Migration of daughter loops toward pole and antipole, side view. (F. H. G.)

Fig. 15.—Arrival of daughter loops at pole and antipole. (F. H. G.)

forms a *star* (Fig. 15). Now, as far as can be seen, there has been accomplished an equal partition of the original reticulum of the nucleus, and the mass divides into two masses which are henceforth distinct nuclei. In each of these two bodies there takes place a reversal of the steps with which the karyokinesis was inaugurated: the V-shaped loops of the stars elongate, their limbs stretch out to the opposite side of the nucleus (Fig. 16), and the skein-like appearance is observed. Then branches are put forth from the main or primary filaments, and

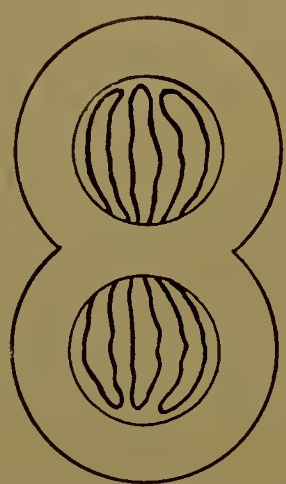


Fig. 16.—Division of nucleus into two nuclei, and elongation of V loops. (F. H. G.)

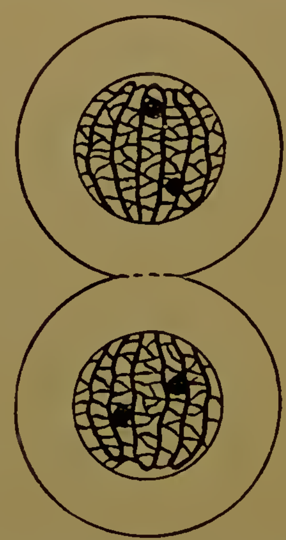


Fig. 17.—Reappearance of secondary filaments and nucleoli. Division of entire cell into two. (F. H. G.)

form the secondary filaments necessary to complete a network. Nucleoli come in sight, and a wall is formed around the nucleus (Fig. 17). Before these last stages are accomplished the protoplasm of the cell shows a constriction which rapidly deepens, and continues to increase until the cell is bitten in two, each part being furnished with a perfect nucleus in which is no sign of a spindle. It is held by some authors that the wall of the nucleus is not complete, and that thus is permitted a mingling of the interstitial substance of the nucleus with the cell-protoplasm. However this may be, nobody questions the intercommunication after the disappearance of the nuclear wall.

Various modifications of karyokinesis are frequently observed, but the foregoing description comprises the main features in a typical and complete case.

CLASSES OF TISSUES.

I. Tissues furnishing the free surfaces of the body : **Epithelial Tissues.**
II. Tissues passively supporting other parts : **Sustentacular Tissues.**
III. Tissues performing a nutritive function : **Liquid Tissues.**
IV. Tissues devoted to movement : **Muscular Tissues.**
V. Tissues essential to sensation : **Nervous Tissues.**

THE EPITHELIAL TISSUES.

Tissues furnishing the Free Surfaces of the Body.

There is a peculiar propriety in speaking of this class first, as it is composed entirely of cells, and also because the male and female cells, by whose union every human being is created, are, to all intents and purposes, epithelial cells.

On every surface which is free, as distinguished from attached, are found multitudes of cells, and with hardly an exception the surfaces are covered with them or, more properly speaking, completely composed of them. Thus, the top layer of the skin is made wholly of cells; so also is the exposed surface of every cavity, tube, or passage which connects directly or indirectly with the skin; as, for example, the alimentary canal from mouth to anus, all of the air-passages, the urinary organs, the generative ways; the surface of cavities which are entirely closed, which cannot be reached without dissection, such as the pleura, the heart, the blood-vessels; and others which need not now be enumerated.

These cells, thus spread out in close contact with each other, are *epithelial cells*, and the sheet of tissue which they form is *an epithelium*. Etymology does not suggest the character of the tissue, the extent of its distribution, its uses, or any other valuable fact about it, the word being derived from the Greek words signifying "upon the nipple." It is best, therefore, to employ it in a perfectly arbitrary way. Many groups of these cells—indeed, all of those which limit the surfaces of shut sacs, shut tubes, and other cavities which are not directly or indirectly continuous with the skin—are called *endothelial*, and the sheet of tissue which is formed by them is named an *endothelium*, the derivation giving it the meaning of "within the nipple"—a term which has not even the minute justification to be accorded to "epithelium;" for there is epithelium upon the nipple, but there is no endothelium within it, except as there is in every part which contains blood- and lymph-vessels. As Macalister most pertinently says, "The distinction between endothelium and epithelium is not always either histologically certain or functionally possible, nor can its development be relied on as a criterion." It would be well if the attempt to keep up the distinction were abandoned; but, as some writers still employ the term endothelium, it is well to understand that they refer to a cellular tissue which develops from what will presently be described as connective tissue. In this book all such will be included under the head of epithelium.

Originally all epithelial cells are nucleated: in most of them the nucleus can be demonstrated at any stage of their existence; but in some it becomes obliterated, usually as the result of pressure or exposure to the drying effects of the air.

The cells almost literally constitute the entire tissue, the intercellular substance being reduced to its lowest terms, and consisting of a minute quantity of a semi-fluid, adhesive material called the *interstitial cement-substance*, which glues the cells together.

Usually an epithelium rests upon a transparent, structureless sheet of extreme thinness, rather difficult of demonstration, the *membrana propria* or *basement membrane*. Though called structureless, it is shown to be made up of flattened plates of typical connective tissue, which will be treated of a little later.

An epithelium contains no blood-vessels and a very diminutive supply of

nerves. When destroyed or in any way lost the cells are regenerated, as a rule, with rapidity.

Epithelium performs many important services, among which may be mentioned the protection which it furnishes to underlying tissues, the prevention of the escape of lymph from the parts which it covers, the absorption of nourishing materials into the blood, the maintenance of motion in the fluid which comes in contact with it, the smoothness which it imparts to surfaces, the formation of secretions, and assistance in the appreciation of certain sensory impressions.

The materials composing epithelial cells and the substance uniting them are sufficiently yielding to permit considerable alterations in their form without injury. Thus, when the structures upon which an epithelium rests enlarge or contract, it readily adapts itself to the changed conditions, without cracking in the one case or wrinkling in the other.

No classification of epithelial cells is very satisfactory, but the study of them is made somewhat easier by the knowledge that (excepting a few—the spheroidal—whose form presents but a slight departure from that of the typical cell) they may be placed in two classes, in one of which they are long and slender, and are arranged with their chief axis perpendicular to the surface, and in the other of which they are broad and thin, with the long axis parallel with the surface upon which they rest.

In the first class—the cells standing on end—are columnar (cylindrical), prismoidal, conoidal (pyramidal), pyriform (pear-shaped), club-shaped, fusiform (spindle-shaped) cells. In the second class—the cells lying on side—are flattened (scaly or squamous) cells (Fig. 18).

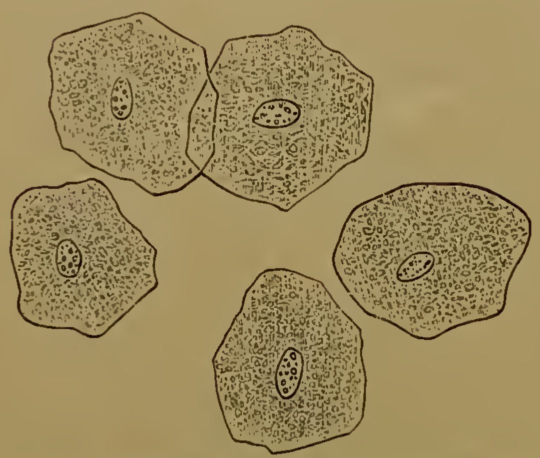


FIG. 18.—Flattened epithelial cells. (Dalton.)

It will be observed that this classification is based upon form only, and that the difference between one and another is accounted for by the direction in which pressure is applied. For example, suppose that a large number of soft, globular cells are placed upon an even plane, side by side, each just touching every immediate neighbor, and imagine that an equal number of exactly similar cells are introduced additionally upon the same area. Of course something must give way, or the proposed problem has no solution; and what actually yields is the shape of each of the plastic cells. The cell cannot go downward, for the surface upon which it rests prevents this; sidewise pressure of every adjacent cell deprives it of a considerable part of its former standing-room; and, as its bulk remains unaltered, it is obliged to move a part of its mass upward, and its free surface, reduced by the lateral squeezing, is thrust two or three times as far from its attached surface as it was originally. The cell has become elongated, changed from a sphere to a cylinder or column, by pressure applied in a number of lateral and parallel directions. If the surface upon which the cells originally rested was convex in every direction, instead of flat, the cells would be changed from spheres to cones or pyramids by pressure made laterally on each at many points, and progressively increasing in force from the part nearest the surface downward. The difference in results depends upon the variation of the supporting surface. If the cells are pressed between two parallel planes, one of which is the surface upon which they rest, the result is a flattened cell. It is easy to imagine how the other and less common shapes have been evolved.

Flattened epithelium is often called tessellated, or pavement, because, when one looks directly down upon it, it presents the appearance of a flagging of stones. The names, however, are objectionable, not only because they are superfluous, but more because they are equally applicable to the columnar variety when it is viewed in the same way; for the flat, free ends of the latter look

as much like a pavement—indeed, are even more suggestive of one than are the others (Figs. 19, 20).

While these classes include nearly all epithelial cells, many cells have peculiarities which are distinguishing, and it is convenient to designate them by descriptive names, such as *ciliated* and *prickle*, from their appendages; *sensory* or *neuro-*, from their relation to the periphery of a special-sense organ; *pigmented*, from their coloration; *goblet* or *chalice*, from their modification of shape; *transitional*, from their being of a rapidly varying form; *glandular*, from their work in secretion. A brief mention of the chief points of each variety is desirable.

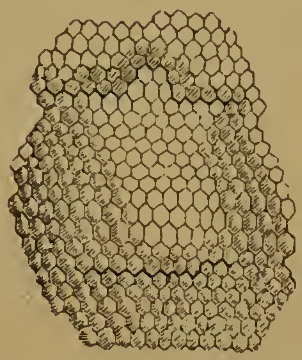


FIG. 19.—End view of a number of epithelial cells, presenting the appearance of a pavement. (Retzius.)

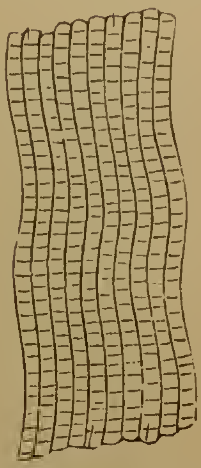


FIG. 20.—Side view of some of the cells of Fig. 19, showing that they are long and slender. (Retzius.)

Ciliated cells (Fig. 21) in man are always of the columnar form, and are characterized by the projection from their free extremity of a number of delicate processes strongly suggestive of eyelashes, and hence called *cilia*. The cilia have a constant vibrating motion, with a strong stroke in one direction and a weak one in the other. They are situated in various parts, but never where they are likely to be subjected to hard usage. Thus, they are nowhere in the alimentary tract, where the masses of food and excrement would injure them; but they exist almost everywhere in the breathing passages, which transmit nothing hurtful to them. Their more powerful stroke is always made in the same direction; thus, in the respiratory tract it is invariably such that the mucus which smears the surface is moved toward the open end of the system—that is, from the deep parts of the lung to the surface of the body. Cilia are found in the adult mainly in the organs of breathing and those of generation.

FIG. 21.—Two conoidal epithelial cells, their free ends furnished with cilia.

Prickle-cells (Fig. 22) exist in the middle layers of the stratified epithelium of the epidermis, the outer layer of the skin. They are polyhedral, and the little spaces between them are bridged over with delicate threads, which break when the cells are separated and present the appearance of short, rigid spines.

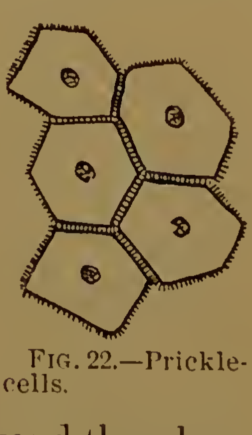


FIG. 22.—Prickle-cells.

Sensory epithelium, or neuro-epithelium cells (Figs. 23, 24), are found in close relation with the filamentous terminals of the nerves devoted to taste, smell, hearing, and sight; from which fact the names *sensory* and *neuro-* ("nerve") are derived. Such a cell is intimately associated at its attached end with the periphery of a sensitive nerve, and at its free extremity is quite generally prolonged into a stiff, hair-like process, which may project beyond the plane of the surrounding surface. These distal bristles receive a shock from a wave of the fluid into which they protrude, and this causes a thrill to pass through the cell and to agitate the nerve-filament, which carries the impression to the nerve-centre.

Pigmented cells are found in various situations. They are of different shapes, generally very irregular, and have been invaded by (perhaps filled with) black particles. In the colored races the lower layers of the epithelium of the skin are highly charged with them.

Goblet or **chalice cells** (Fig. 25) are a modification of the cylindrical or conoidal, and their names are explanatory of their form. The nucleus retreats to the attached end of the cell, and the rest of the cell becomes filled with a granular material. The granules swell, causing the part in which they are contained to bulge out at the sides and crowd over into the territory of the adjacent cells; and, finally, the internal pressure becomes so great that the cell bursts at its free end, its contents escaping upon the surface as a glairy substance called *mucus*. A goblet-cell, therefore, is a one-celled gland, doing real secreting work. In the true mucous glands the secreting cells are of this variety. A goblet-cell may soon return

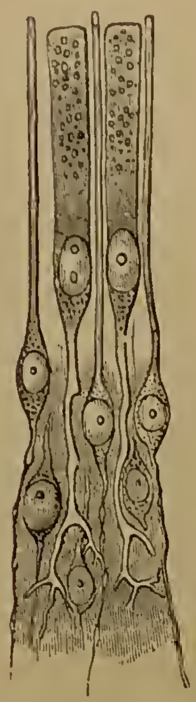


Fig. 23.—Neuro-epithelial cells. Three cells project beyond the general surface, and are supported by intermediate cells. (Frey.)

Fig. 24.—Neuro-epithelial cells. Two send long processes beyond the general surface. (Schultze.)

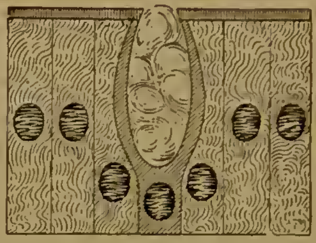


Fig. 25.—Goblet-cell, surrounded by cylindrical cells.

to the condition of an ordinary cylindrical or conoidal cell or remain a chalice for a long time.

Transitional epithelium (Fig. 26) partakes of the features of a number of other groups. Its typical illustration occurs in the bladder, where the superficial layer is composed of thick, flattened cells, with dimples on their under surface into which the large ends of pear-shaped cells of the next layer are received, the spaces between the last being filled with the inverted cones of the lowest set.

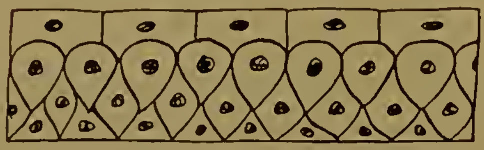


Fig. 26.—Transitional epithelium.

No two layers are alike, and a lower is in a state of transition to a higher plane.

Glandular epithelium (Fig. 27) is composed of cells of differing shapes—cuboidal, cylindrical, conoidal, polyhedral, and spheroidal, the last being rarely found except in the remotest recesses of tubular and racemose glands. The various forms of these cells are accounted for by the different shapes of the cavities to which each series is compelled to adapt itself. The function of glandular cells is secretion.

Fig. 27.—Glandular epithelium as seen in a salivary gland. At the lower right-hand corner is a duct lined with conoidal epithelial cells. (Kölliker.)

When an epithelium consists of only one stratum of cells it is called *simple* or *single-layered;* when it has two or more layers it is known as *stratified.* If a ciliated epithelium is stratified, only the cells of the upper layer are furnished with cilia.

THE SUSTENTACULAR TISSUES.

Tissues Passively Supporting Other Parts.

1. *Mostly fibrous.*
   (*a*) White Fibrous Tissue (Connective Tissue Proper).
   (*b*) Yellow Fibrous Tissue (Elastic Tissue).
   (*c*) Areolar Tissue.
   (*d*) Adipose Tissue.
   (*e*) Gelatinous Tissue.
   (*f*) Adenoid Reticular Tissue.
   (*g*) Neuroglia.
2. *Cartilaginous.*
   (*a*) True Cartilage.
   (*b*) White Fibro-cartilage.
   (*c*) Yellow Fibro-cartilage.
3. *Osseous.*
4. *Dentinal.*

The members of this large group present many violent contrasts in their physical qualities: we find the soft and the hard, the transparent and the opaque, the flexible and the rigid, the nearly liquid and the almost stonily solid, the fibrous and the granular, the moist and the dry, the colorless, the white, the yellow, the pearly, and the pink. And yet, in spite of these antipodal traits, the individuals making up this class have certain common characteristics which distinguish it from all others. One which strikes the attention most forcibly is the absolute passivity of every member of it: not one of them does anything actively; they stand still like stocks and stones, and are acted upon by the other tissues; they originate no action. But the service which they perform, though humble, is of essential importance, and is measurably presented to the mind by any one of the various names borne by the group. "Sustentacular" suits our purpose excellently, suggesting mechanical support, the upholding that requires strength and endurance. "Connective substance" is good, as referring to a very prominent function—the uniting of neighboring parts. "Connective tissue," of course, inherently carries an equal significance, but the term has been so much used to designate a leading member of the group, that it is not always certain to convey one's intent to include all of them. "Skeletal" is highly descriptive to one who has divested his mind of the popular notion that nothing but bony structures are entitled to be considered a skeleton. Probably the best term of all in our language is "framework," because everybody knows that a framework may be made of any materials which have suitable physical qualities, and understands that it does the work of supporting mechanically, of connecting near and distant parts of the whole, and of keeping these same parts away from each other—the last being an office quite as important as the more prominently mentioned connective work. As, however, the term is so little used in a titular way by anatomists, another has been selected to distinguish the group.

The word "framework," like "skeletal," to an anatomist suggests far more than the massive, bony staging, which is the gross basis of the human form. To him it means the delicate, and even microscopic, rafters, beams, and shelves, which serve to give definite shape to minute organs and to small parts of large structures, and to keep their active portions from pressing upon and being pressed upon by each other. So, too, in his mind, "connective" has both macroscopic and microscopic applications. It is a name given to the tissue of which are made the bands which tie the bones together, and the strong, flexible sinews which unite contractile organs to the parts which they move; and it is equally deserved by minute parts which, on a small scale, do work of a comparable kind.

These tissues are very widely distributed in the body—so extensively, indeed, that their diffusion may almost be declared to be universal. If every particle of material except the sustentacular tissues were to be withdrawn from the body of a person with whom we were well acquainted, there would be no difficulty in recognizing him, even in minute details of form.

It is interesting to observe not only that the sustentacular tissues are similar in a functional way, but that they are structurally allied. They originate in the same elements of the embryo, to a certain extent they are interchangeable, and they often shade into each other.

They consist of cells and intercellular substance, though in most of them, when mature, the cellular elements are inconspicuous, and the material between the cells is so largely developed as to constitute almost the entire bulk of the tissue.

White Fibrous Tissue.

The name of this tissue is highly descriptive, for it is distinctly white when seen in a mass, and its fibrous character is manifest. It is often called "connective tissue proper," or even merely "connective tissue," because of its great abundance, both absolute and comparative, and its very wide distribution; but, while its conspicuousness among the sustentacular tissues entitles it to the name which implies the fact, the designation is confusing, and would better be dropped in favor of the descriptive appellation which is here chosen. Teased out with needles and viewed with the microscope, it is seen to consist almost wholly of extremely fine, colorless fibrils, arranged side by side in bundles which have an undulating outline (Fig. 28). The fibrils may be very long—some inches—and do not branch. Closely applied to the bundles of fibrils are cells; but these are not a prominent feature in the adult tissue, and are liable to escape attention unless staining agents are used. The cells proper to the tissue are flattened, irregular, nucleated, granular, and have long processes (Fig. 29).

Fig. 28.—White fibrous tissue.

Fig. 29.—Cells of white fibrous tissue, often called connective-tissue cells.

White fibrous tissue is distinguished chiefly for its great strength and flexibility, and is found where these qualities by themselves are needed. For example, it is almost the only tissue in most of the bands (ligaments) which fasten the bones together, and in the cords (tendons) by which the force of muscular tissue is transmitted to and applied at distant points. In these situations great strength is required, for without it the bones would readily become dislocated and the muscular contractions would be fruitless of result; flexibility is demanded, since rigid ligaments and tendons would either prevent movement or break, and thus prove useless. If, in addition to strength and flexibility, elasticity were added, the bones would get out of place during many movements, and muscular contraction, instead of moving the object to which the distal end of the tendon was attached, would be devoted in large part to the stretching of the tendon itself.

These illustrations will show that this tissue is well fitted by its physical qualities to make up the ropes, cords, protective sheets, and outer shells of organs.

Yellow Fibrous Tissue.

This texture is composed mainly of fibres, and in large masses presents a delicate yellow hue, from which facts it is named. Under the microscope its fibres are seen to differ materially from those of white fibrous tissue: they are ribbon-like, thick, branched, and curled at the ends into hooks, which result from their fracture in the preparatory teasing (Fig. 30). The chief physical properties of this tissue are strength, flexibility, and elasticity, the last being that which distinguishes it from all others, and gives it the name by which it is often known, "elastic tissue." Elasticity, the quality which restores bodies possessing it to their normal shape after distortion, is not to be confounded with contractility, the attribute which enables a body to shorten a diameter (for example, to draw its two ends nearer to each other) under the influence of a stimulus. Elasticity is a merely passive property: it cannot display itself until some outside force has stretched or otherwise deformed the substance in which it resides; but contractility is active, and is manifested under influences which have no such effect upon elastic bodies. The elasticity of yellow fibrous tissue, while disqualifying it for the work of tendons, eminently fits it for other duties, and it is found performing valuable service in many places. Wherever it is located, it does precisely such work as india-rubber would do, if similarly arranged. It is commonly associated with white fibrous tissue, though in relatively small quantities. The amount of it in the system is not large as compared with that of white fibrous tissue. The clearest masses of it are the ligamenta subflava between the laminæ of the vertebræ. Its strength is not equal to that of the white fibrous.

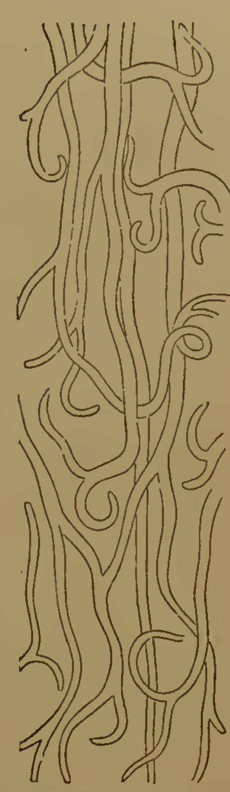


FIG. 30.—Yellow fibrous tissue. (Queckett.)

Areolar Tissue.

Areola is the Latin word for "a little space," and areolar tissue gets its name from its appearance of being full of minute spaces. It is sometimes called "cellular tissue"—a term which has no justification to the histologist, to whom the word "cell" has come to have an arbitrary meaning, entirely independent of its etymology. The designation "cellular tissue" is applicable properly only to a texture made up substantially of the histological elements called cells—such a tissue, for instance, as epithelium.

In areolar tissue we discover no material different from those which we have already studied—only a new arrangement of some of them. It is composed of a mixture of white and yellow fibrous tissues, so disposed in irregularly criss-crossed bundles as to make a network, the meshes of which bound innumerable areolæ (Fig. 31). The bulk of each bundle is white fibrous tissue, and around it are loosely twined threads of yellow fibrous tissue. The little spaces between the meshes are not definitely walled, but are indescribably irregular cavities, which communicate in the freest way with each other (Fig. 32). The fasciculi are moistened by a lymph-like fluid, which contributes to their flexibility and diminishes the friction between them.

Areolar tissue is found almost everywhere subjacent to the skin and mucous and serous membranes, between muscles, blood-vessels, nerves, and other parts. It forms a layer which is attached on one side to the deeper structure, on the other side to the more superficial. When one of these structures moves, the areolar tissue permits it to slide upon the other for a little distance, the wavy bundles of white fibrous tissue being straightened out, and the narrow ribbons of yellow fibrous being put on the stretch. The motion ceasing and the disturbing

agency being removed, the strained yellow fibres assert their elasticity, pull the white fasciculi back into their undulations, and assist a little in the restoration of the parts between which it lies to their former attitude of repose. The tissue is connective in a typical sense.

Disease and accident afford striking illustrations of the freedom of intercommunication of the areolæ,

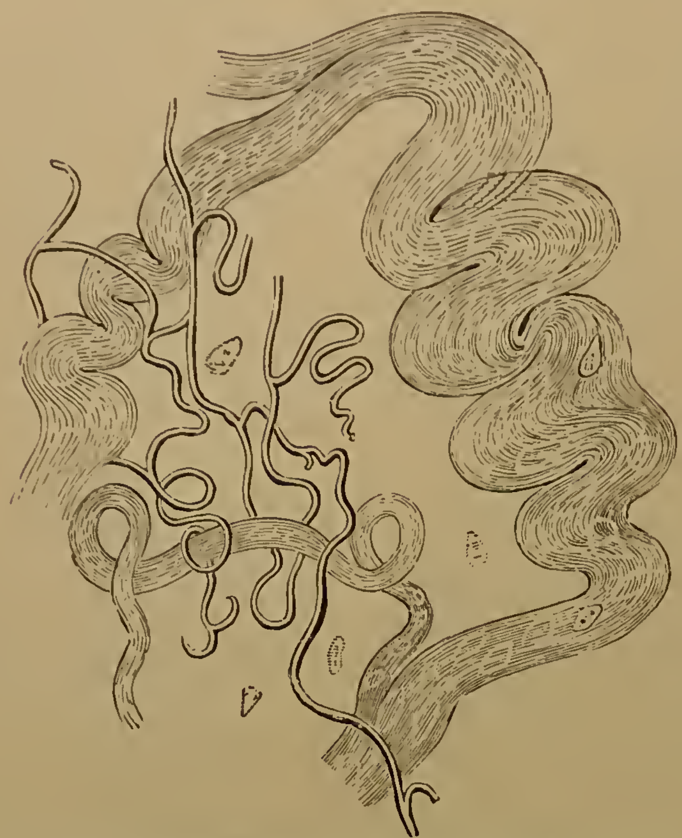


FIG. 31.—Areolar tissue, composed of bundles of white fibrous tissue and branched strands of yellow fibrous tissue loosely intertwined.

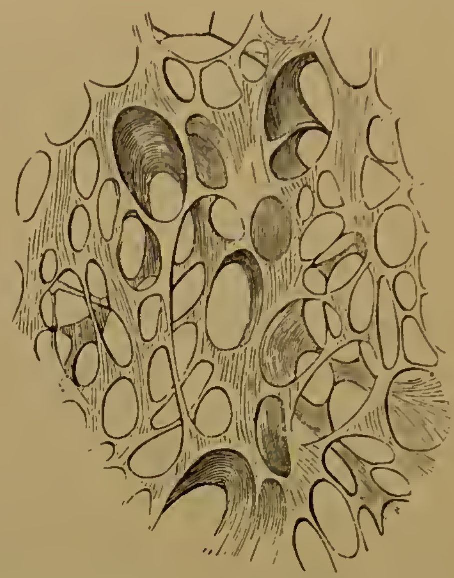


FIG. 32.—A portion of areolar tissue inflated and dried, showing areolæ.

and also of the vast extent of this structure just beneath the skin—here called the subcutaneous areolar tissue. The lymph-like fluid mentioned above is sometimes formed more rapidly than is normal, or, what amounts to the same thing in effect, its absorption is less rapid than its formation, and the excess accumulates in the areolæ. But, as each of these spaces opens into all of its neighbors, the fluid gravitates from one to another into those which are most dependent, and these it distends proportionately to its amount. In such a case, when the feet have been upon the floor all day, by evening they are swollen; but, after the patient has passed a night in bed in the horizontal position, the enlargement disappears almost entirely, because the fluid has gravitated back again and has become widely diffused. Sometimes, as in fracture of a rib, a sharp fragment of bone perforates the chest-wall and slightly punctures the lung, leaving an open tract between some of the air-vesicles of the latter organ and the areolar tissue near the surface of the body. Every time that air is drawn into the lung, some of it escapes through the accidental opening into the subcutaneous areolar tissue, the spaces of which become inflated, at first only in the region of the injury, but at each breath more and more extensively, until finally all of the areolæ under the skin are so ballooned that the victim presents such an appearance as is shown in Fig. 33.

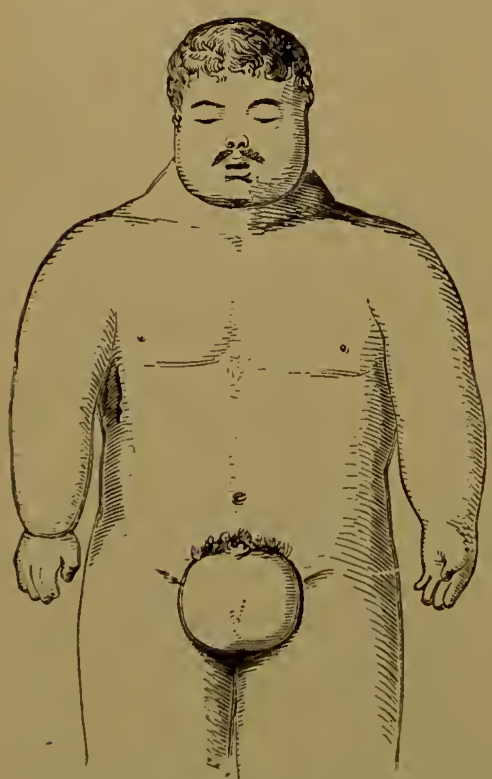


FIG. 33.—Inflation of subcutaneous areolar tissue, due to introduction of air through a wound in the chest-wall and lung. (Gross.)

The areolar tissue around certain organs, as vessels, becomes somewhat condensed and forms a distinct sheath. The nourishing vessels of a part are situated in its areolar tissue. In the narrow spaces between the lobules of a solid organ, as the liver; forming a layer outside of the mucous coat of hollow organs, as the

stomach; everywhere among bundles of fibres, as in muscle,—in all such situations is areolar tissue, furnishing a springy bed for the blood-vessels. Indeed, it may be laid down as a rule that vessels are developed in this sort of tissue, and always continue to occupy it.

Adipose Tissue.

Areolar tissue has been described as composed of white and yellow fibrous tissues, disposed in such a way as to leave irregular spaces between their bundles. Some of the cells of the white fibrous tissue of this combination in certain circumstances undergo peculiar changes. The outer layer hardens, forming a delicate cell-wall; the most of the substance of the cell is converted into liquid oil; and the nucleus, previously central, is crowded off to one side, thus becoming peripheral, and is fastened to the cell-wall. Thus is formed a *fat-cell* (Fig. 34)—a veritable sac of liquid oil, deserving the name "cell" in the etymological as well as in the histological sense. Such cells are lodged in the

FIG. 34.—Fat-cells: *a*, filled with oil; *b*, exhausted of oil, the cell-wall shrivelled. (Kölliker.)

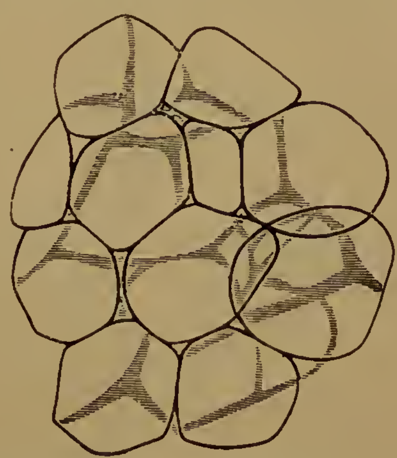


FIG. 35.—Fat-cells packed closely together, and thus becoming polyhedral.

spaces of areolar tissue very generally; but in a few localities they are never seen—the penis, the eyelids, the cavity of the cranium, and the lungs (excepting a little near the roots). When the number of fat-cells is sufficient to fill the areolæ even moderately, the *tissue* is called *adipose* or *fatty*. The cells are round or ovoid, except when they are closely packed, and then the mutual pressure produces angular facets all over them (Fig. 35). Fatty tissue is yellow, soft, and resilient when living, but hard when dead. Its amount is very variable, and there is no absolute criterion of the normal quantity. But when its shifting line of healthful development is overstepped, obesity or corpulence is reached—a pathological condition which may interfere with the proper performance of vital functions. Sometimes the fat in the abdominal wall attains a thickness of six inches.

The uses of adipose tissue are various. It is a cushion for organs—the kidneys always lie in a bed of fat, and other organs are similarly provided, though less lavishly. Being a slow transmitter of heat, it is a protection against cold—it is always found in the great serous apron which hangs down in front of the bowels, and doubtless serves to keep them warm. Adipose tissue is a reservoir of nutrient material which is drawn upon in starvation. If an animal is deprived of suitable food, his system relies largely upon its store of fat in the emergency. If a wolf and a sheep are starving, each feeds upon its own fat, the herbivorous animal becoming for the time practically a carnivorous one, since it lives on fat mutton. A man wasting with fever lives on his own tissues—cannibalistically consumes human flesh. The adipose, being a cheap tissue, is used most freely; nervous tissue, the most costly, suffers the least loss of weight. During the process of starvation the oil is abstracted from the cells, and the walls become wrinkled and collapsed. The nucleus, however, keeps alive; and, when nourishment is again appropriated by the system, the nucleus becomes active, takes from the blood the materials suitable for the manufacture of oil, combines them properly, and deposits the product in the cell-cavity, which soon becomes plump again. Finally, it is not unworthy to mention the æsthetic effect of a reasonable amount of adipose, which softens the asperities of sharp angles, and contributes to the production of the graceful contours, which are so essential to perfect beauty of form.

Gelatinous Tissue.

This tissue is jelly-like, as its name implies. It is also called *mucous tissue* and *mucoid tissue.* No typical example of it occurs in the adult body; but the gelatin of Wharton in the umbilical cord illustrates it perfectly. Here is seen a protoplasmic network, formed by the union of the processes of cells, which are identical with those of white fibrous tissue. In the meshes of this reticulum is a semifluid ground substance. This tissue is the most immature form of fibrous tissue.

The vitreous body (or humor) of the eye is composed of gelatinous tissue; but the fibrous element is so slightly developed that its existence is by some observers denied, and almost all of the cells have disappeared, the few which remain being shrunken and indistinct. The vitreous is in large part (about 99 per cent.) water, and its appearance is that of a mass of beautifully transparent, colorless, and delicate jelly.

The service performed by the vitreous is strictly sustentacular. It is the stuffing which keeps the ball of the eye in its globular shape, preventing the wrinkling of the retina, which would be utterly destructive of definiteness of sight. When lost, the vitreous is not restored, having a low vitality and practically no recuperative power.

Adenoid Reticular Tissue.

The word *reticulum* is the diminutive of the Latin *rete,* "a net," and consequently means "a little net." "Adenoid" comes from the Greek word for "gland," and signifies "gland-like." *Adenoid reticular tissue,* therefore, means the tissue forming the network in gland-like structures, particular reference being had to the framework of the so-called lymphatic glands, which are far better named "nodes," since they are not real glands.

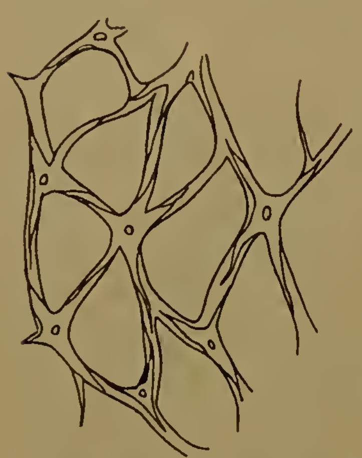


FIG. 36.—Adenoid reticular tissue.

This network has points of resemblance to areolar tissue—may, indeed, be regarded as a modification of it. The reticulum consists of strands of white fibrous tissue, with few, if any, yellow fibres intermingled, and these delicate trabeculæ ("little beams"), which support the proper substance of the node, are nearly or quite covered by fibrous-tissue cells in the shape of broad, thin plates closely applied and wrapped around them (Fig. 36).

Though the most characteristic display of this tissue is in the lymphatic nodes, it is widely distributed in the body, and is particularly abundant in mucous membranes.

Neuroglia.

Literally, the word *neuroglia* means "nerve-glue," and is misleading, for it is used as the name of a network supporting the nerve-substance of the brain

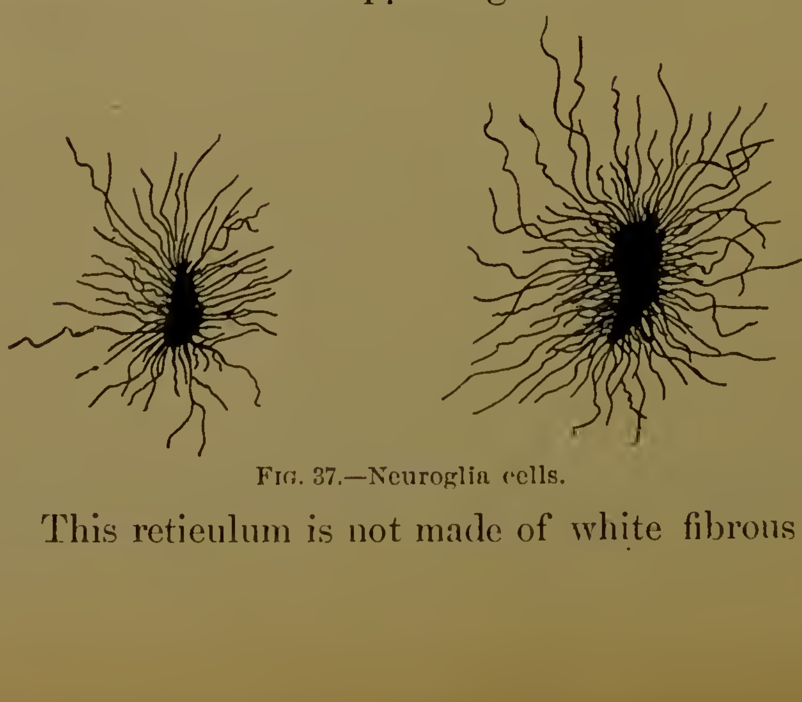


FIG. 37.—Neuroglia cells.

and spinal cord. This reticulum is not made of white fibrous tissue, as is that

of adenoid tissue, but is eomposed of peculiar bodies, called glia-eells, and their proeesses. The eells (Fig. 37) are irregular and stellate, and their branehes are frayed out at the end in tufts of minute fibrils, which ramify everywhere between the nerve-eells and fibres.

Besides the neuroglia, there are two other means of meehanieal support for the tissues of the great nervous eentres. From the attached portion of the epithelial cells whieh line the cavities of the brain and spinal cord delieate fibrils run peripherally and end in the pia, the fibrous and vaseular eovering of these masses. Finally, the pia itself sends prolongations inward, which are of manifest sustentaeular value.

Cartilaginous Tissues.

Cartilage, popularly called "gristle," is a dense tissue, but much less hard than bone, elastie, and serving important skeletal uses.

It oecurs in three varieties:

True or Hyaline Cartilage.
White Fibro-eartilage.
Yellow Fibro-eartilage.

Hyaline cartilage is so named from the Greek word for "glass," because of the transpareney of a thin sliee of it. It is also ealled *true cartilage,* beeause it is the only variety whieh presents pure and unmixed the features which eharaeterize this tissue. It enerusts the parts of bones whieh enter into the eomposition of movable joints, in sueh situations, being ealled artieular eartilage; it forms the extensions of the ribs to or toward the breast-bone; it eonstitutes the bulk of the larynx; it stiffens the windpipe and bronchial tubes with strips and plates; it is the framework of the front of the nose, and does similar service in one or two other plaees. Hyaline cartilage is opaque, bluish-white, firm, elastie, and readily and smoothly eut with a knife. Covering it closely is a eoat, ealled *perichondrium* ("around the eartilage"), which has an outer fibrous and an inner eellular layer, and is the agent by which the protection and growth of the eartilage are effeeted. Under the mieroscope eartilage is seen to eonsist of small elusters of roundish, nueleated cells (Fig. 38), each group erowded into a little eavity (*lacuna,* "a little lake"), between which and its neighbors is an expanse of apparently homogeneous intereellular substance (*matrix*). The cells are modified fibrous-tissue cells (the so-called eonneetive-tissue eells), and the matrix is really eomposed of extremely delicate fibrillæ, the mass of which is pervaded by minute lymph-channels. Cartilage is non-vaseular, and the nourishing material for the parts farthest from the surfaee permeates the tissue through these lymph-paths.

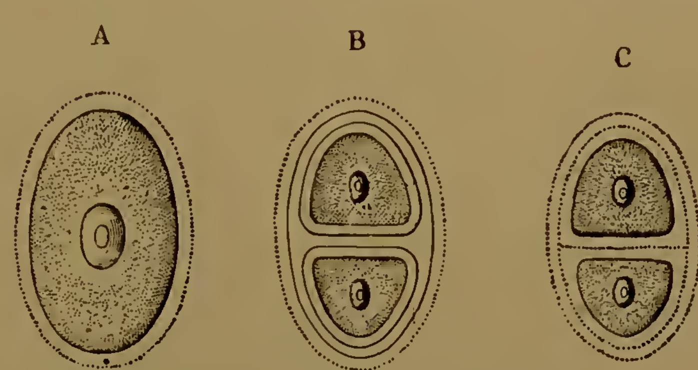


FIG. 38.—Cartilage-cells: *A*, mother cell; *B*, *C*, daughter cells. (Testut.)

White fibro-cartilage is otherwise known as *fibrous cartilage* and *fibro-cartilage.* It makes the great disks between the bodies of the vertebræ, the plates at the movable symphyses, the masses between the bones in the freely-movable joints, and the nodules which strengthen tendons in exposed situations. It has no proper perichondrium, and, indeed, is more like tendon than it is like true eartilage. Microscopically (Fig. 39), it is seen to consist of a dense

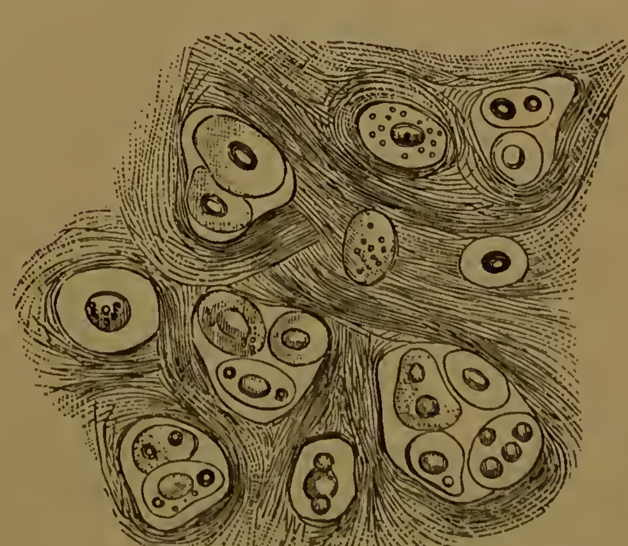


FIG. 39.—White fibro-cartilage.

felting of white fibrous tissue, imbedded in which are nests of cartilage-cells, as if the seeds of cartilage and those of connective tissue proper were sown together in the same field and developed in an intimate mixture. The physical properties of the tissue are such as would be expected from such an association of ingredients—elasticity from one element, flexibility and toughness from the other.

Yellow fibro-cartilage is called also *elastic cartilage* and *reticular* ("network") *cartilage*, for structural reasons which will presently be manifest. Its principal examples are the framework of the auricle and that of the epiglottis in the larynx. It is opaque and yellowish, and more elastic, flexible, and tough than hyaline cartilage. Viewed with the microscope, it is seen to consist of a close network of yellow fibrous tissue, containing scattered groups of true cartilage-cells (Fig. 40)—a composition which readily explains its physical qualities.

As both the second and third varieties of cartilage have a fibrous tissue mingled with the true cartilage,

FIG. 40.—Yellow fibro-cartilage. (Kölliker.)

the names "fibro-cartilage" and "fibrous cartilage" do not differentiate one from the other. As all cartilage is elastic, the name "elastic cartilage" is not clearly helpful in the designation of that containing yellow fibrous tissue; and "reticular" is no better as a title for the third variety than is "fibrous" for the second, since in each its fibrous tissue is arranged as a network. The names which are given above are preferred because they actually convey a correct idea of the structure of each form respectively.

Osseous Tissue.

The word "osseous" is derived from the Latin *os*, meaning "a bone." Osseous tissue, therefore, is bony tissue, and it is the characteristic material in the bones. A bone is one of the numerous hard organs, which, taken together, make up the skeleton. One of the long bones of the limbs will show typically all of the features which we need for the study of osseous histology.

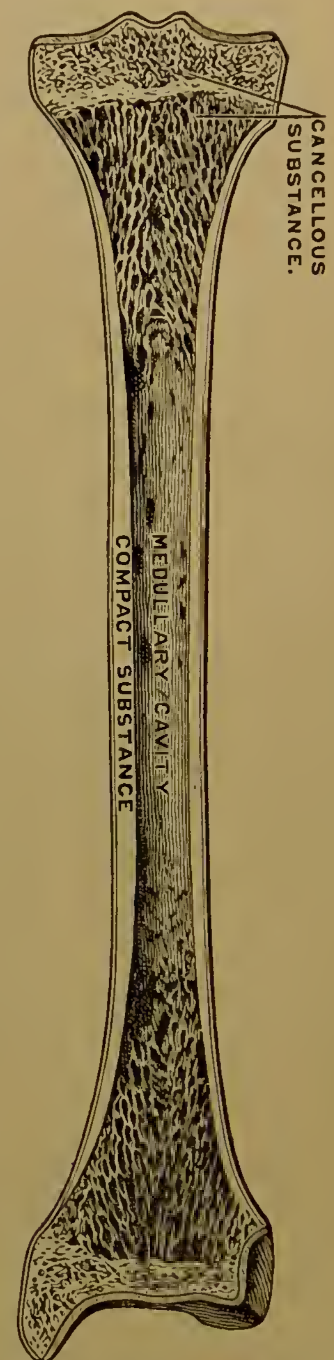


FIG. 41.—Vertical section of a long bone. (Testut.)

A long bone has a central cylindrical portion, the shaft, and an expanded portion at each end. The parts of the extremities of the bone which present surfaces in movable joints are crusted over with a layer of cartilage, and the rest of the bone is covered with a fibrous and vascular membrane, called the *periosteum*, meaning the structure "around the bone." The fibrous part of the periosteum makes it protective; the vascular serves for the nourishment of the bone. The deepest portion of the periosteum is composed of cells, called *osteogenetic* ("bone-begetting"), because essential to the formation of osseous tissue. If the bone is divided into halves by a vertical cut, its shaft is found to be hollow (Fig. 41). The open space is called the *marrow-cavity*, and is lined by a fine,

fibrous layer, the *endosteum*, meaning the structure "within the bone." The material in the outer parts of the bone is very dense, and is, consequently, known as *compact osseous tissue*. It is very thick in the shaft, but shades off toward the expanded extremities, and in them is merely a thin shell. The residue of the bone has the appearance of a network, with the finest meshes nearest the outer surface, the coarsest next to the marrow-cavity. It is called *spongy osseous tissue*, on account of its porous character, and *cancellous*, from its being a latticework. But compact and spongy are terms which have reference only to gross appearances, which are caused by the arrangement of the material: the structure is essentially the same everywhere. The *marrow-cavity* is occupied by the *marrow* or *medulla*, a very vascular material, containing many peculiar bodies (*marrow-cells*), which are largely changed into oil as adult life is approached, the color of the marrow being, therefore, altered from red to yellow.

Osseous tissue is one of the hardest materials in the body, being surpassed in density by two tissues only—dentine and enamel—both of which exist in the teeth. It is very tough and elastic, as well as hard, and will resist great strain without breaking. It is composed of two kinds of substance, earthy and animal, so intimately commingled that, if either is removed, the other maintains the form of bone even in its minute details. The earthy matter, which is mostly salts of lime and makes up two-thirds of the weight of the bone, can be removed by the action of a dilute acid. The bone is thus decalcified, and consists of a brownish, tough, flexible, and elastic material, so free from stiffness that the bone, if a very long one, may be tied into a knot (Fig. 42). The animal matter can be driven off by heat. When this has been done, the bone is white, rigid, and brittle to the last degree: it can be crushed into fragments between the thumb and finger. In the fresh condition the color of bone is delicate pink in the compact portion, deep red in the cancellated.

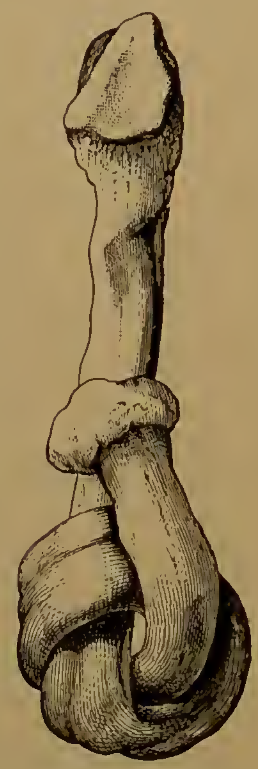


FIG. 42.—Human bone which has been deprived of its earthy matter and tied in a knot. (Dalton.)

If the shaft of a long bone is sawed in two transversely, and a very thin slice is removed from the cut surface and examined with the microscope, it will be seen that there are numerous nearly circular or oval perforations, around each of which is a series of concentric rings, which represent long, hollow cylinders fitted accurately one over another, so as to form a solid rod perforated from end to end (Fig. 43). This constitutes a *Haversian system*, named from the celebrated anatomist, Havers. The concentric rings are *lamellæ* or *laminæ* ("layers"), and the hole in their midst is a Haversian canal. In the solid substance of the rod are numerous small excavations called *lacunæ* ("little lakes"), from which radiate in every direction fine channels, called *canaliculi* ("little canals"), which, by uniting with those from neighboring lacunæ, establish a free communication between the Haversian canal and the lacunæ farthest away from it. The lacunæ and canaliculi are lymph-paths, and are important agents in the nutrition of the bone. The Haversian canal is occupied by blood-vessels, nerves, and lymphatic vessels, all imbedded in a mass of areolar tissue. The canals have a general longitudinal direction, but some run more obliquely and connect the more vertical. Immediately subjacent to the periosteum and parallel to it is a series of lamellæ which form a continuous sheath for the more central parts, and are called *circumferential lamellæ*. A similar arrangement obtains at the inner free surface, several concentric lamellæ encircling the medullary cavity, and standing in the relation to it that the Haversian lamellæ do to their central canal. Indeed, this inner circumferential series with its contained marrow has been called a mammoth Haversian system. In the spaces between the Haversian systems are series of layers arranged at irregular angles to each other. They are called *intermediate lamellæ*, and, like the inner and outer

circumferential, are of periosteal formation, the remnants of an earlier stage of growth than is shown in any Haversian system.

The lacunæ are occupied by nucleated corpuscles, called *bone-cells,* fine processes of which extend into the canaliculi. Lacunæ and canaliculi are characteristic of osseous tissue, and are found in all true bone. But Haversian canals are not present in plates of bone which are so thin that sufficient nourishment is afforded by blood-vessels upon their opposite surfaces, as in many lamellæ of the cancellous tissue, and frequently in a part of the lachrymal bone.

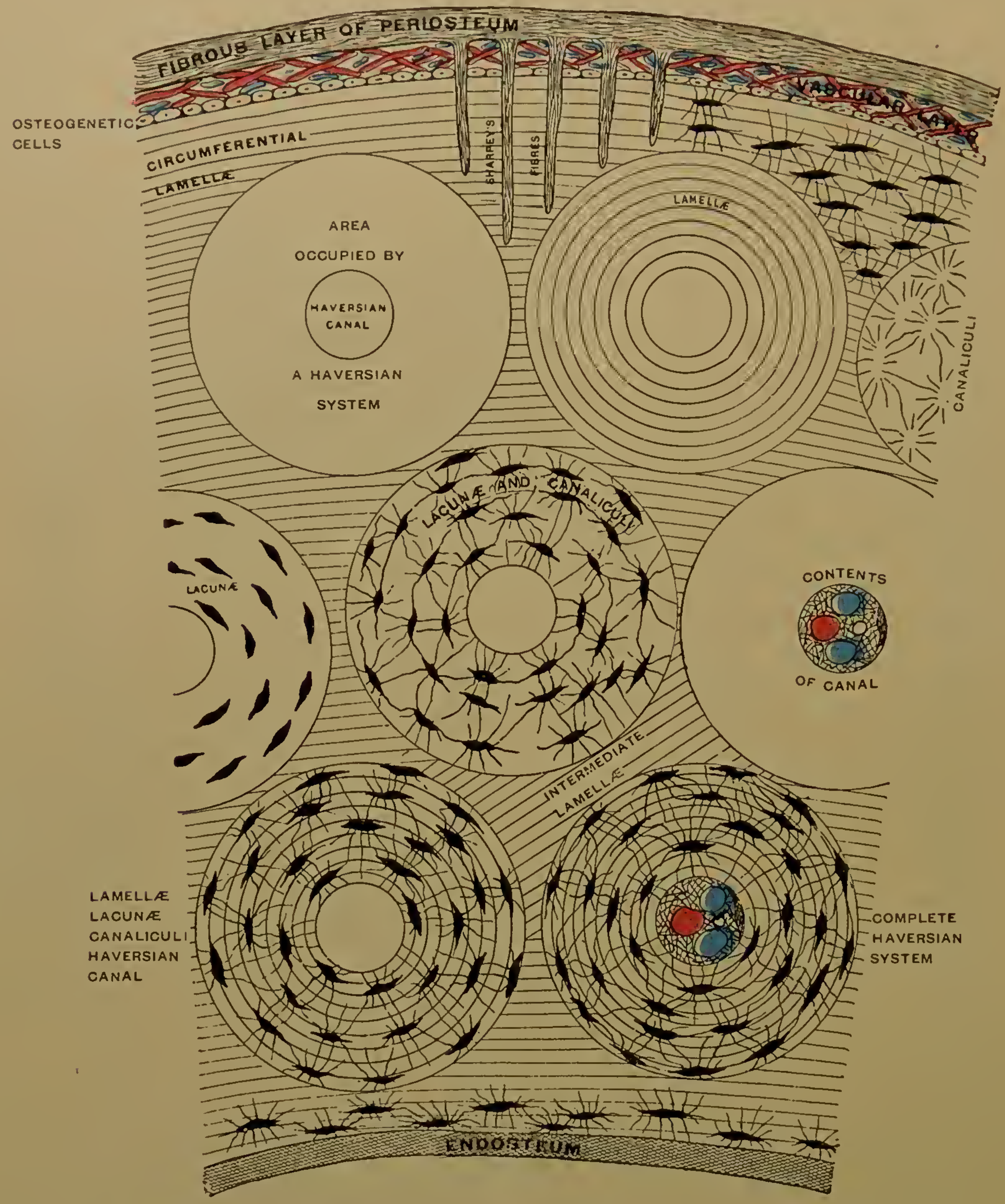


FIG. 43.—Diagram of the structure of osseous tissue. A small part of a transverse section of the shaft of a long bone is shown. At the uppermost part is the periosteum covering the outside of the bone; at the lowermost part is the endosteum lining the marrow-cavity. Between these is the compact tissue, consisting largely of a series of Haversian systems, each being circular in outline and perforated by a central canal. In the first one is shown only the area occupied by a system; in the second is seen the concentric arrangement of the lamellæ; and in the others, respectively, canaliculi; lacunæ; lacunæ and canaliculi; the contents of the canal, artery, vein, lymphatic, and areolar tissue; lamellæ, lacunæ, and canaliculi; and, finally, all of the structures composing a complete system. Between the systems are circumferential and intermediate lamellæ, only a few of which are represented as lodging lacunæ, though it is to be understood that lacunæ are in all parts. The periosteum is seen to be made up of a fibrous layer and a vascular layer, and to have upon its attached surface a stratum of cells. From the fibrous layer project inward the rivet-like fibres of Sharpey. (F. H. G.)

If a thin layer is peeled off of the surface of a decalcified bone, minute projections from its under surface may be seen. These are inward prolongations of the periosteum, and are known as the perforating *fibres of Sharpey.* They are not found in Haversian systems, but only in the circumferential and intermediate lamellæ, which, as has been already said, are developed from the periosteum. They seem to contribute to the strength of the portions of bone in which they

exist by riveting them together; and they certainly make the attachment of the periosteum firmer by giving it a more than superficial hold. Tendons, when attached to bone, are prolonged into it as perforating fibres.

A delicate, longitudinal sliver of bone is seen to have minute openings, which

FIG. 44.—*A*, transverse section of a long bone, natural size; *B*, the dark part of *A*, magnified 20 diameters. Haversian systems of different sizes are seen, with canals, lamellæ, and lacunæ. The enlargement is not sufficient to show canaliculi. At *b* is a portion of the cancellated tissue. (Peaslee.)

represent the tracks of canaliculi; and, if the flake is superficial in origin, larger holes also appear wherein have lain the perforating fibres. Between the apertures is a very fine reticulum of fibrillæ, showing the essentially fibrous character of the tissue and its consequent homology with ordinary connective tissue.

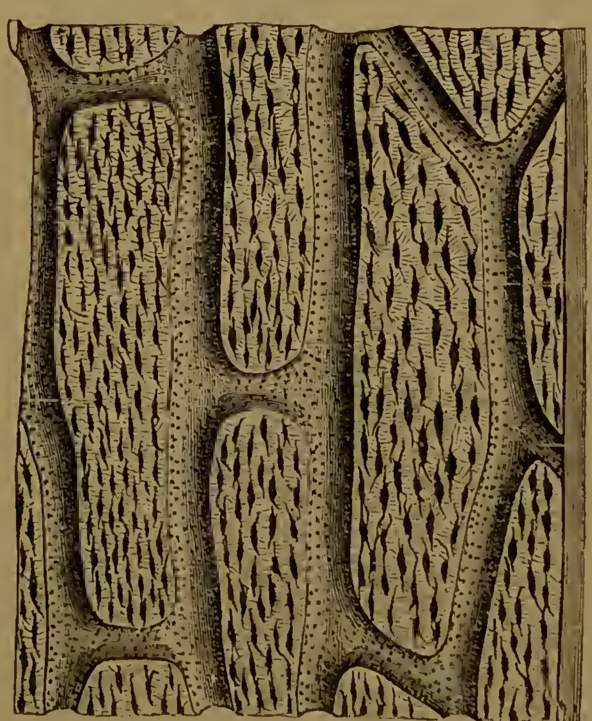


FIG. 45.—Longitudinal section of compact osseous tissue, greatly magnified. The Haversian canals are cut lengthwise. The dots in the canals are the openings of canaliculi. (Testut.)

Marrow fills the cavity of the shaft of the bone and extends into the interspaces of the cancellous portion. Its elements are supported on an areolar network, and it is extremely vascular, especially in the spongy bone, where, on account of the great number and size of the vessels, its color is red. In the shaft of an adult bone the marrow has been mostly changed into adipose tissue, and is yellow. In the marrow are multitudes of cells, like those of fibrous tissue, and they are called *marrow-cells*. There are also great, irregular masses, with many nuclei—*giant-cells*. The marrow and the contents of the Haversian canals are practically identical; indeed, they are continuous one with the other, and the comparison of the marrow and its encircling lamellæ with the Haversian canal and its surrounding lamellæ is not fanciful.

From what has been said, it will be understood that osseous tissue consists of cells, fibres, and an interstitial substance, which is saturated with lime salts; and, consequently, that the feature in which

it principally differs from white fibrous tissue is its impregnation with this earthy matter.

It is important to remember that the integrity of the periosteum is essential to the proper nourishment of bone, and, if it becomes peeled off by accident or by disease, it should be replaced speedily in order to prevent death of the part which it supplies with blood.

Dentinal Tissue.

Dentinal tissue gets its name from the fact that it makes up the bulk and determines the form of the teeth, the Latin for "tooth" being *dens*. A tooth has a crown, the part which projects from the gum; a fang or root, the part buried in the jaw; and a neck, the narrow and sometimes constricted part embraced by the edge of the gum. If a vertical section is made through the middle of a tooth (Fig. 46) which has a single root, there is brought to view a long central cavity, containing the

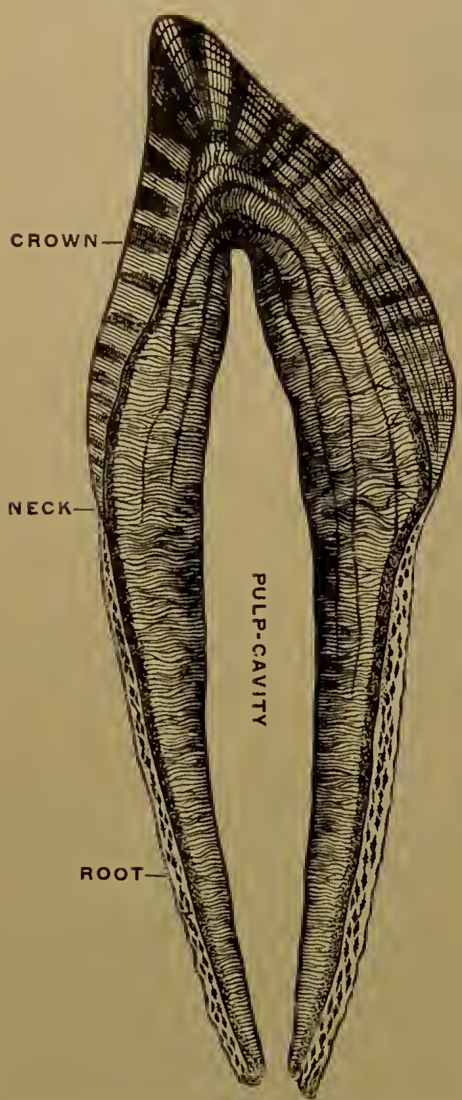


FIG. 46.—Tooth in vertical section.

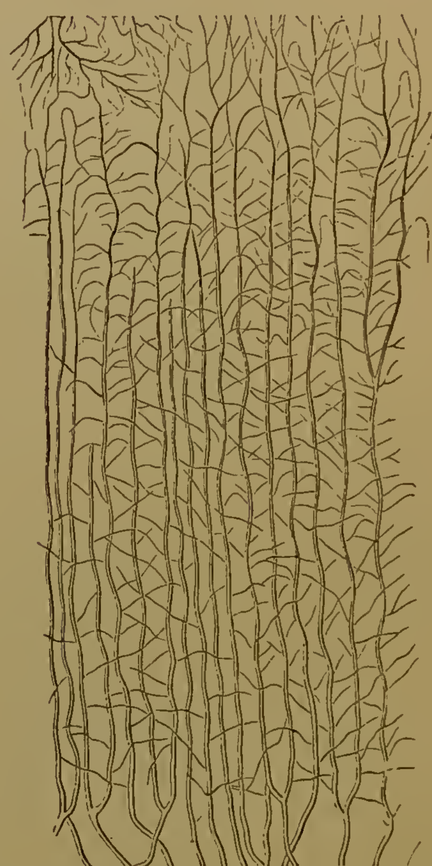


FIG. 47.—Dentinal tubules, in longitudinal section. The lower part of the cut shows the portion of dentine near the pulp-cavity. (Kölliker.)

pulp, the latter being composed of vessels and nerves, supported on a staging of areolar tissue, and also a great number of cells of the connective-tissue class arranged at the periphery of the cavity. Around this pulp-cavity is the hard portion of the tooth, in which are three different tissues: a crust of epithelial tissue all over the crown, the enamel; a crust of osseous tissue all over the fang, the cementum; and the main mass of the structure, the dentine or ivory.

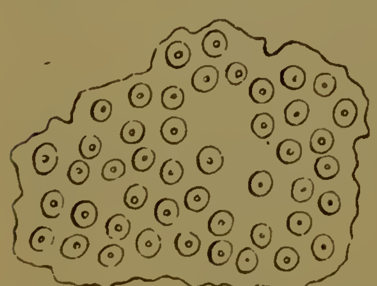


FIG. 48.—Dentinal tubules in cross-section, showing their cavities, walls, and the intertubular substance.

The *dentine* is white, very dense, closely allied to bone, than which it is a little harder. It is developed from closely-packed white fibrous tissue, which becomes infiltrated with lime-salts. This compact mass is riddled with minute channels, *dentinal tubules* (Fig. 47), which radiate in wavy lines from the pulp-cavity in every direction, except at the tip of the fang, where there is an opening through which pass

the vessels and nerves. The tubules branch as they pass toward the surface of the tooth, and the matrix is particularly dense just around them, thus forming a thick wall for each (Fig. 48). The peripheral pulp-cells, called *odontoblasts* ("tooth-germs"), send delicate processes into the tubules. The undulations of the microscopic tubules produce an appearance of striation which is visible to the naked eye.

THE LIQUID TISSUES.

Tissues Performing a Nutritive Function.

An elaborate presentation of the liquid tissues is not needed in an elementary work on anatomy, for a knowledge of them, except in a superficial way, is not required for the comprehension of the description of macroscopic structures. Consequently, they are treated here in a cursory manner, and the student is referred to his text-book on physiology for more detailed accounts of them.

The liquid tissues are—

The Lymph.
The Blood.

They originate in connective tissue, but are so different from it in appearance, physical properties, and function as to merit consideration in a group by themselves.

The Lymph.

Fine and closely stowed as are the elements of the tissues, there are between them spaces, mere chinks and crannies, extremely diminutive and indescribably irregular, into which ooze from the blood of neighboring vessels nutrient materials, and from the tissues themselves the substances which result from their waste. Thus, the tissues are constantly bathed in a mixture of their food and excrement. The spaces containing this fluid communicate freely with each other, and open into the beginnings of minute and delicate tubes, which last, uniting with others of similar size, form larger tubes; these pursue a like course, and so on until tubes of considerable capacity are reached. The little crevices and the tubes are respectively *lymph-spaces* and *lymph-vessels*, and their contents are called *lymph*. The word "lymph" etymologically means "water," but histologically and physiologically it is much more than this. It varies in composition in different parts, being poorest at the periphery and richest near the centre. Examined microscopically, it is seen to consist of a clear, fluid portion, *liquor lymphæ* ("the liquid of the lymph"), and a cellular portion, the latter floating in the former, so that this is a tissue whose intercellular substance is liquid. The cells are *lymph-corpuscles*, and are spheroidal, granular, jelly-like, colorless bodies, averaging $\frac{1}{2500}$ inch in diameter each, with a vaguely defined nucleus, and capable of amœboid movements. They are sometimes called *leucocytes* ("white cells"), because of the whitish appearance of a mass of them.

The lymph-vessels which absorb lymph from the small intestines contain, during the intestinal digestion of food, not only ordinary lymph, but also products of the digestive process. This mixture is called *chyle*, and is milky-looking from the fact that, like milk, it contains a large proportion of oily material finely subdivided—pulverized, we would say, if it were a solid.

The Blood.

Like the lymph, the blood is a tissue composed of cells and a liquid intercellular substance. The fluid portion is called *liquor sanguinis* ("the liquid of the blood") or *plasma*. In it float microscopic particles of various kinds (Fig. 49), of which the most conspicuous and easily demonstrated are the colorless and the colored corpuscles, the former, though without a tint, often being called white, and the latter, though yellowish, red, because, when seen in heaps, they present respectively the hues which these names suggest.

The *colorless corpuscles* are globular, granular, about $\frac{1}{2500}$ inch in diameter, and possess nuclei which are indistinct during the life of the cell. At rest they display amœboid movements. This description will be seen to coincide with that of the lymph-corpuscles; and this will not be surprising to one who has learned that the lymph-stream pours incessantly into the current of blood, so that what is at one moment a lymph-corpuscle, at the next, having entered the blood-vascular system, is a blood-corpuscle. The colorless corpuscles are divisible into a number of varieties, which are chiefly differentiated by means of staining tests.

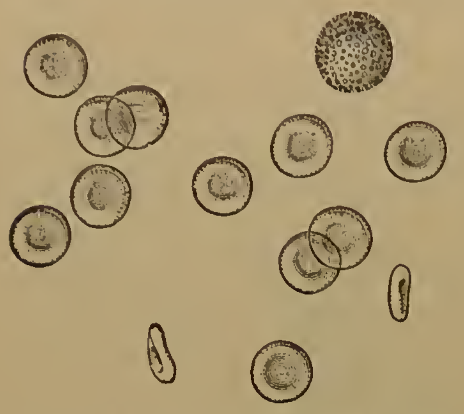


Fig. 49.—Blood-corpuscles. One colorless corpuscle is seen at the top; the others are colored. (Dalton.)

The *colored corpuscles* are very abundant, numbering perhaps five hundred to one of the colorless, and making about one-half of the volume of the blood. They are circular, non-nucleated discs, with rounded edges and centrally depressed surfaces, smooth, amber, transparent, flexible, elastic, and about $\frac{1}{3333}$ inch broad. Besides these bodies are others, inconspicuous and somewhat difficult of demonstration, which need not be mentioned here.

The blood is contained in the chambers and tubes of the blood-vascular system, from which it does not normally escape, excepting in the spleen, where it courses in wall-less channels, and in the case of women during menstruation, when it is discharged through ruptures in the vessels.

THE MUSCULAR TISSUES.

Tissues Devoted to Movement.

Contractility is in some degree an attribute of various tissues. The typical and original cell manifests its amœboid movements by virtue of its contractility, which it brings to bear now in one direction, presently in another. The cilia on the free surface of an epithelium are made to perform their rhythmical lashings because of contractility in their cells. But the muscular tissues alone depend upon this property for the sole functional quality which distinguishes them. Their contractility is displayed on a macroscopic scale, and results in the active movements by which locomotion of the body and changes in the relation of its different parts are effected.

We distinguish three kinds of muscle, which differ anatomically, and, for the most part, physiologically also. They are—

1. Plain muscular tissue.
2. Cross-striped muscular tissue.
3. Cardiac muscular tissue.

Plain Muscular Tissue.

This tissue is known by a variety of names besides that just given. It is called *smooth*, for the same reason that it is called *plain*, because of the usual appearance of its cells; *non-striated* or *unstriped*, to distinguish it from the second kind of muscle, which is characterized by a regular criss-cross of lines on its cells; *involuntary*, from the fact that it is not under the control of the will; *vegetative* and the *muscular tissue of organic life*, because it aids directly in the performance of those offices which are classed as vegetative—in the organic action which is beneath consciousness.

It is found, for the most part, in the walls of the hollow organs, as, for example, the alimentary tube, the urinary bladder and the tubes leading to and from it, and the arteries and veins.

It is made up of cells (Fig. 50) which typically are fusiform; but their ends

are sometimes forked instead of being single-pointed, and sometimes the spindle shape is lost by the rounding of the extremities. Often there is observed a faint appearance of lines running lengthwise, as if the cell were trying to develop into a striped fibre. A transverse cut shows that the cell has flattened sides, evidently the result of pressure from forcible contact with its fellows. The cell is always nucleated, and generally beyond each end of the nucleus is a little collection of granules. The cell has a delicate structureless sheath. The length of the cells varies between $\frac{1}{500}$ and $\frac{1}{10}$ inch, the greater part being very small. In some situations, as in the arterioles, the cells are separate; but usually they are associated in such a way as to make bundles (*fasciculi*) or layers (*strata*), being united by a small amount of adhesive material. The cells are aggregated with much regularity, the bulge of one being adjusted to the tapering tips of its nearest neighbors (Fig. 51). When distinct bundles are formed, they are usually attached at their extremities to some other structure through the agency of a fibrous prolongation.

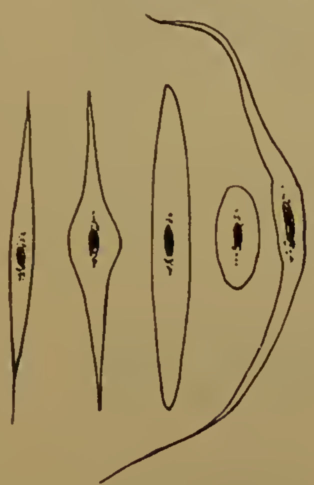


FIG. 50.—Cells of plain muscular tissue.

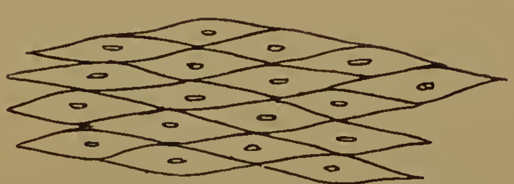


FIG. 51.—Cells of plain muscular tissue arranged in a sheet.

Cross-striped Muscular Tissue.

This variety, also, like the plain, has a number of other names: *striped* or *striated*, from its microscopic appearance; *voluntary*, because the most of it is under the control of the will; the *muscular tissue of animal life*, because, while it has little direct effect upon the organs of the vegetative functions, it is largely concerned in those manifestations which are peculiar to animals. This tissue makes up a very considerable part of the bulk of the body, is principally connected with the bony skeleton, and is that material which, in other mammals, is called "flesh" or "lean meat." It is commonly found in coherent masses, of varying but definite shape, each of which, taken in connection with a fibrous prolongation at each end, is known as a muscle.

The histological unit of cross-striped muscular tissue is a *muscle-fibre*, which is the homologue of the cell of the plain muscular tissue. This fibre is like a long cylinder, with somewhat flattened sides, and rounded or conical ends. It is completely enveloped in a very delicate sheath, the *sarcolemma* ("the flesh-husk"). When examined under an objective of moderate power, it seems to be marked with delicate, longitudinal, parallel, and equidistant lines, and with broad, transverse, regularly placed bands or stripes, from which the ordinary names of striated or striped (better, cross-striped) originate (Fig. 52). Between these cross-stripes are lighter areas, which, with a stronger objective, seem to be divided by a fine line. The cause of these peculiar appearances is not manifest until the tissue is studied with a microscope of great power, but then it is found that they are deceptive. There are no continuous bands or lines running transversely, and the apparent breaks in the longitudinal continuity of the cross-lines are an illusion, caused by the extreme fineness of the contractile material at regularly alternating intervals. The accompanying diagram (Fig. 53) will illustrate this. The fibre is represented as composed of a series of threads placed side by side in longitudinal rows. Each of these threads is a fibril (*fibrilla*), and is marked by alternating bulges and constrictions, regularly placed, and arranged in the following order: a long, wide, fusiform bulge, a constriction, a small, globular bulge, a constriction, and so on

from one end of the fibril to the other. Or, to put it in a different way, a fibril looks like a fine thread, upon which are strung large, spindle-shaped beads and small, round beads, regularly alternating, and leaving a little of the thread exposed between each bead and its two neighbors. These fibrils do not touch each other, but between them, and also separating them from the sarcolemma, is a thin (probably fluid) substance, called *sarcoplasm*. The fibrils are the contractile por-

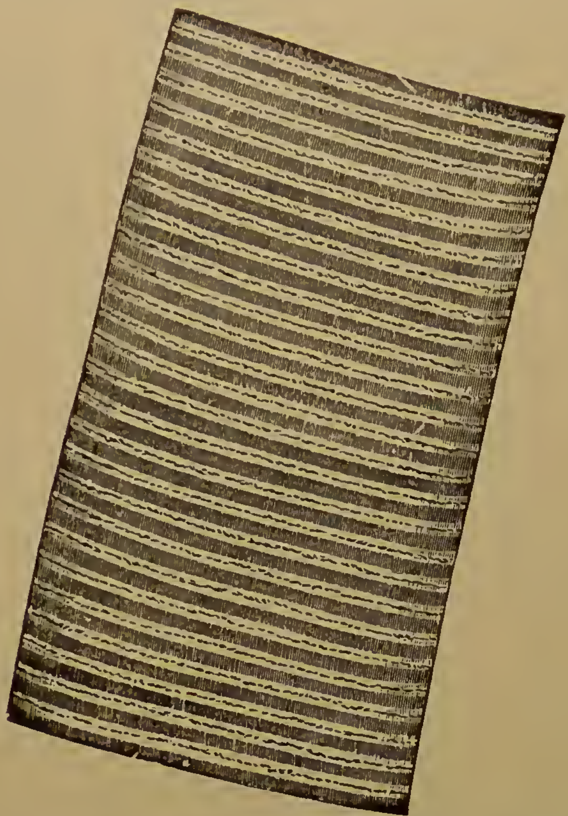


FIG. 52.—Part of a fibre of cross-striped muscular tissue, showing the alternating bands.

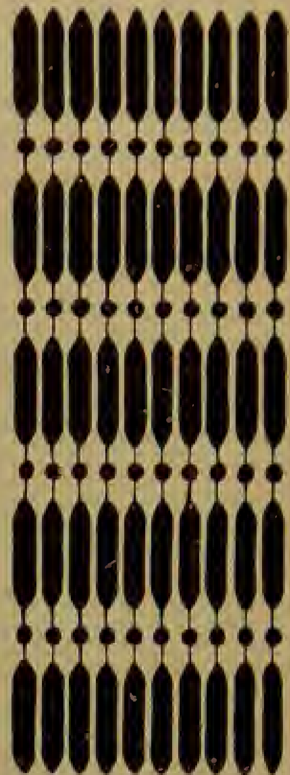


FIG. 53.—Diagram showing the minute structure of cross-striped muscular tissue.

tion of the fibre, and, when they contract, their spindles and beads shorten in the line of the long axis of the fibre, and swell out in the lateral direction. This causes a displacement of the sarcoplasm, which, consequently, pushes out the sarcolemma, and thus produces regularly placed protrusions along the surface of the fibre.

If the diagram is viewed at a distance (as across the room), which will obscure some of its details, the effect is very like that produced by the examination of a fibre of muscle with a microscope of mod-

FIG. 54.—Fragment of a fibre of cross-striped muscular tissue, showing fibrils separated at one end by teasing.

FIG. 55.—Fragment of a fibre of cross-striped muscular tissue, hardened, showing transverse cleavage. (Kölliker.)

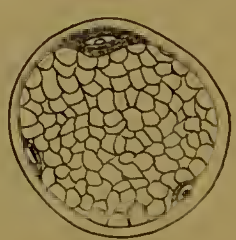


FIG. 56.—Transverse section of muscle-fibre, showing nuclei. (Testut.)

erate power—faint, longitudinal lines and broad, transverse stripes, the latter separated by light intervals, which are crossed from side to side by a thin, dark streak.

The spindle portion of the fibril is called a *sarcous element;* the round beads in a single transverse plane constitute what is known as *Krause's membrane*.

In the teasing of a bit of muscular tissue with needles, it happens that many fibres are torn, and the broken ends of the fragments sometimes are frayed out

like a coarse brush, the fibrils standing for the bristles (Fig. 54). When the fibre has been hardened by certain reagents, it will occasionally show a cross-cleavage, by which it is divided into discs (Fig. 55).

Upon the inner surface of the sarcolemma are scattered a number of oval nuclei, the *muscle-corpuscles* (Fig. 56), so unobtrusive that they generally escape observation unless reagents are used in the examination. They are regarded as nucleated accumulations of the sarcoplasm.

In a fibre are many groups of fibrils, each collection being called a *muscle-column*. The fibres are aggregated in bundles (*fasciculi*), and the bundles are assembled in the contractile portion of the muscle. The fibres may be 2 inches long and $\frac{1}{250}$ inch thick, or only a tenth part of these measurements. In muscles or fasciculi whose length is greater than that of their component fibres the latter are joined to each other end to end. Fibres commonly do not branch; but in some of the lingual and facial muscles terminal divisions may be observed.

The fasciculi, as a rule, run from one end to the other of the contractile part of a muscle; but exceptions occur in double-bellied muscles and in others which have a tendinous interruption of the muscular continuity. The fasciculi, from the closeness with which they are packed, have flattened sides, and are thus more or less prismoid.

As has been said above, each fibre has, as its true and perfect investment, the *sarcolemma*. Between the fibres is a delicate areolar tissue continuous with a thicker layer of the same, which sheathes the fasciculi; and this is merely an inward prolongation of a still more pronounced lamina which coats the entire muscle. The outer tunic (Fig. 57) of the muscle is called *epimysium* ("upon muscle"); the sheaths of the bundles constitute the *perimysium* ("around muscle"); and the tissue between the fibres is the *endomysium* ("within muscle"). All of these are continuous, each with the others, and all are composed of areolar tissue.

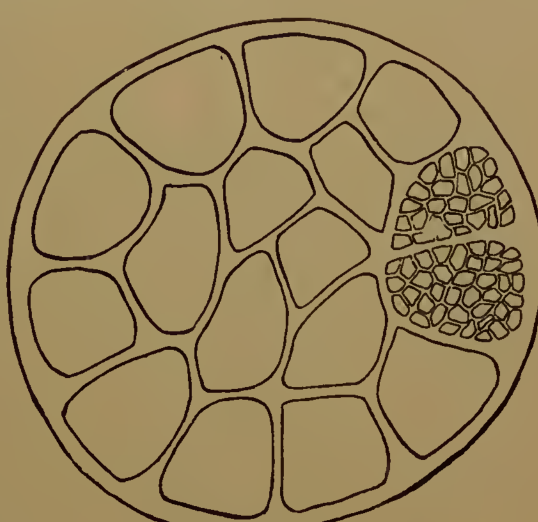


FIG. 57.—Sheaths of muscular tissue in cross-section. The muscular tissue does not appear, but is represented by the spaces between the partitions. Outside of the entire muscle is *epimysium*; between the bundles is *perimysium*; between the fibres is *endomysium*—the last shown in two areas at the right. Diagrammatic. (F. H. G.)

Fibres which end in tendon come to it either in line with its axis or obliquely to it. The sarcolemma of the end of the fibre is very closely attached to the tendon, and there is a continuity of the areolar tissue between the fasciculi of the muscle and that between the bundles of the tendon. In these ways the two parts of the muscle are so firmly united that their separation by violence is extremely rare.

The blood-vessels course between the fibres in the areolar tissue, making a network of long meshes. Lymphatics, also, are numerous in the areolar tissue, and the nerves of the muscle are abundant.

Cardiac Muscular Tissue.

The muscular tissue of the heart has peculiarities, which ally it to the plain muscular tissue on the one hand and to the cross-striped on the other. It is like the former in being composed of nucleated cells, and in being beyond the control of the will; it resembles the latter in being cross-striped, and in presenting in a mass a color similar to that of voluntary muscle. The cells (Fig. 58) are short, branched at one end, cross-striped (though with less regularity and plainness than in the case of ordinary striated muscle), and are not furnished with sarcolemma. The cells are connected with their

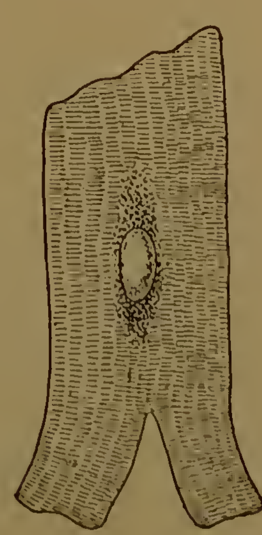


FIG. 58.—Cell of cardiac muscular tissue. (Testut.)

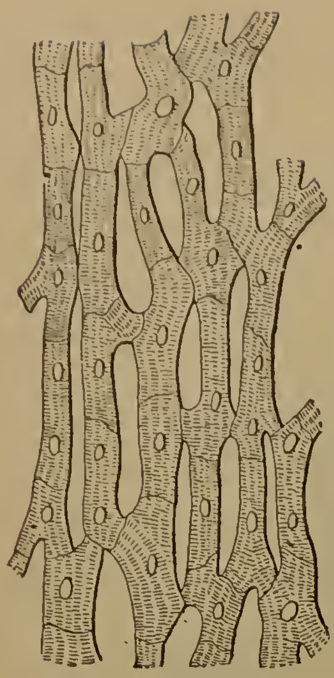


Fig. 59.—Cardiac muscular tissue, the cells united in a network. (Testut.)

neighbors by an abrupt union, and form fasciculi and networks (Fig. 59). The cardiac muscular tissue has a remarkably abundant supply of blood- and lymph-vessels.

THE NERVOUS TISSUES.

Tissues Essential to Sensation.

The nervous apparatus is conveniently considered under two heads—the central portion and the peripheral portion. The former comprises the brain and spinal cord, and is otherwise known as the cerebro-spinal axis; the latter includes the cords which radiate from this axis, and also the ganglia ("knots") upon these cords. In both the central and the peripheral regions two kinds of tissue are recognized, which are distinguished by their color as gray and white. The white is much the more abundant in both regions, but there is a great deal more of the gray in the central than there is in the peripheral. Functionally regarded, the gray matter is that which receives impressions, retains, converts, and marshals them in various ways, and originates impulses: it is the part which feels, thinks, remembers, wills; the white matter merely conveys impressions and impulses, connecting the gray matter with distant parts and associating one portion of it with another. The gray is cellular; the white is made up of fibres. Nerves consist of fibres of this kind, grouped together in bundles of small or large size.

The *gray nervous tissue* is composed essentially of cells, called *nerve-cells* or ganglion-cells. These vary greatly in shape and size in different parts, but they all have certain common features which are characteristic. They are granular, nucleated, usually pigmented, and have projections or processes which are called poles. At least one pole of a cell is prolonged as a nerve-fibre (Fig. 60), and thus it is seen that there is a structural connection between the two

Fig. 60.—Nerve-cell. All of the processes are protoplasmic except that marked *a*, which is the axis-cylinder process; *b* indicates a clump of pigment-granules. (Gerlach.)

kinds of nerve-tissue. The other processes of the cell—of which there may be many—radiate from its general mass, divide again and again, and terminate in minute twigs, which mingle with, but do not become continuous with, corresponding ramifications from neighboring cells. These processes are called protoplasmic processes or *dendrites* ("tree-like"). A nerve-cell, with its dendrites, and the nerve-fibre which is continuous with the cell, constitute a *neuron* (Fig. 61). The neuron is the unit of structure of nervous tissue.

The *white nervous tissue* (called white on account of the appearance of a mass of it) is made up of fibres which vary in diameter and length, but have their

main difference in the presence or absence of a certain coat. The simplest, because least clothed, of the fibres are small, pale, fibrillated, nucleated threads of tissue, whose component fibrillæ are the minutest independently recognizable portions of the tissue. Such a thread is called a *pale fibre*, and also bears the name "non-medullated," on account of the lack of the tunic which distinguishes the other kind. It sends off minute filaments at a right angle with its course soon after emerging from the cell, and then continues without further branching until near its end, where it divides into bundles of fibrillæ, each of which splits up into smaller bundles, and so on, until the fibre has frayed out into its ultimate filaments.

Besides the pale fibres is a more numerous class, called *white* or *medullated fibres*. A typical representative of this variety has three parts, of which the first and essential is centrally located, and from this fact is named the *axis-cylinder* (axis-band or axial fibre). The axis-cylinder is like a pale fibre, being fibrillated, giving off fine, lateral twigs near its origin, and dividing into its ultimate fibrillæ at its periphery in the same manner.

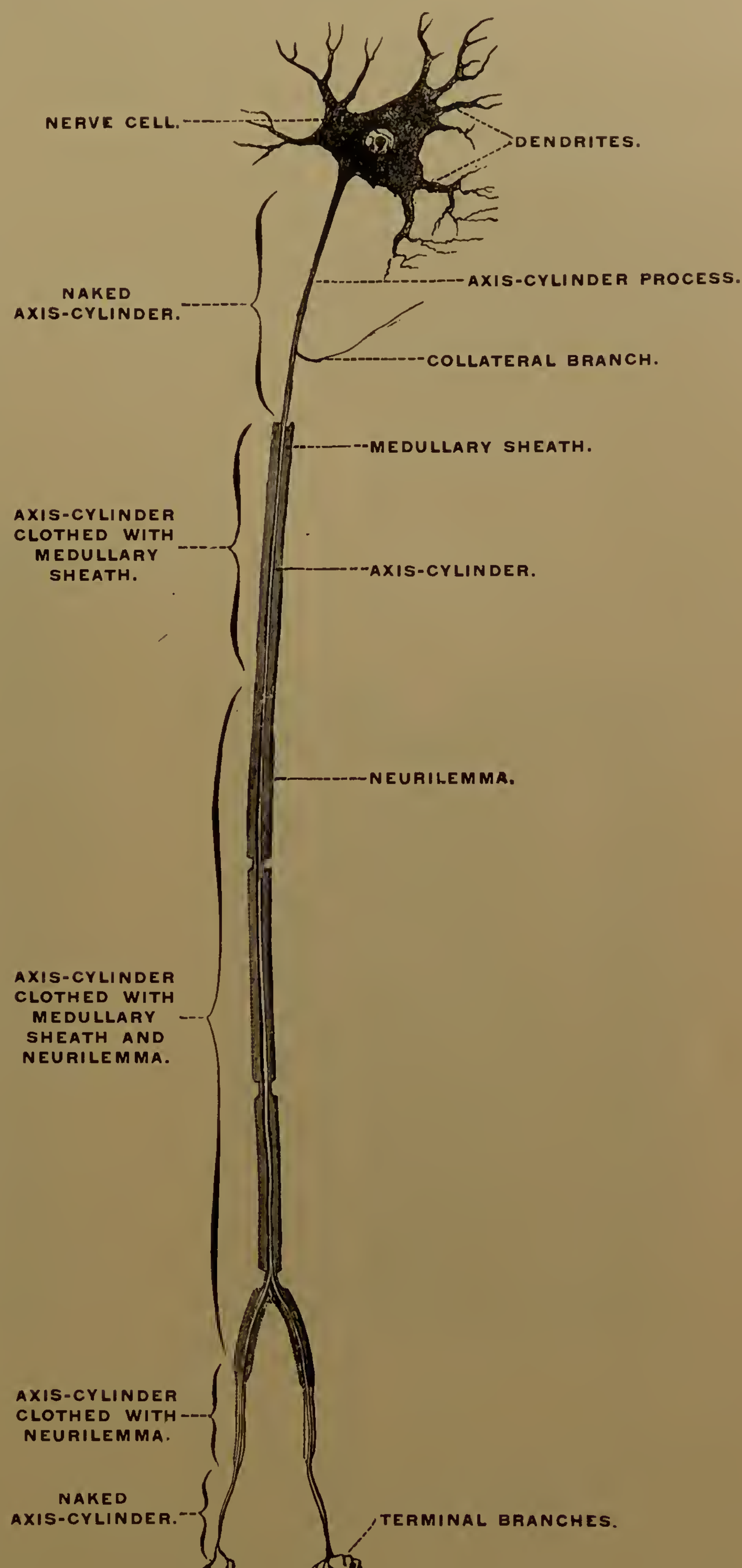


FIG. 61.—A neuron. (Stöhr.)

Outside of the axis-cylinder is a thick, insulating tunic, composed of a soft, oily material (myelin), and known as the *medullary sheath* or white substance of Schwann. Surrounding this first coat is a second, very delicate and thin, but sufficiently strong to keep the medullary sheath in shape. It is called the *primitive sheath*, *neurilemma* ("nerve-husk"), or nucleated sheath. The medullary sheath is evenly spread upon the axis-cylinder, excepting at regular intervals, where it is lacking for a minute space, thus leaving the primitive sheath as the sole covering of the fibre. At these places the fibre presents the appearance of being encircled with a cord so tightly as to squeeze the medullary substance away from the part. These constrictions are known as the *nodes of Ranvier*, and the lengths of fibre between them are called the *internodes* (Fig. 61).

The primitive sheath has on its inner surface a nucleus for each internode, midway between the ends of the latter. Either or both of the sheaths may be lacking; and in the latter case the axis-cylinder alone is left, and we have a pale fibre instead of a white one. In brief, the axis is always present as the one essential thing in a nerve-fibre; if it is coated with the medullary sheath, it is a white fibre; and it may be in one part naked and in another clothed. There is no break in the continuity of the axis from one end to the other. The filaments or fibrillæ composing it are held together by a cement called *neuroplasm*.

A number of nerve-fibres gathered into a coherent bundle constitutes a *funiculus* ("little rope"). It is enclosed in a sheath of laminated fibrous tissue, called *perineurium* ("around nerve"), from the innermost layer of which shelf-like trabeculæ project between irregular groups of nerve-fibres, and compose the *endoneurium* ("within nerve"). A single funiculus with its wrappings may constitute a nerve; but usually a number of funiculi are grouped together in a nerve, and, when this obtains, they are kept in close relation to each other by a common sheath, the *epineurium* ("upon nerve"). The bundles in a nerve have a network arrangement, each funiculus splitting up more or less at short intervals, and its component fibres passing into neighboring funiculi (Fig. 62). The fibres, however, always retain their individuality: while they cross and recross in the nerve, and any one of them may be an ingredient of many funiculi in passing

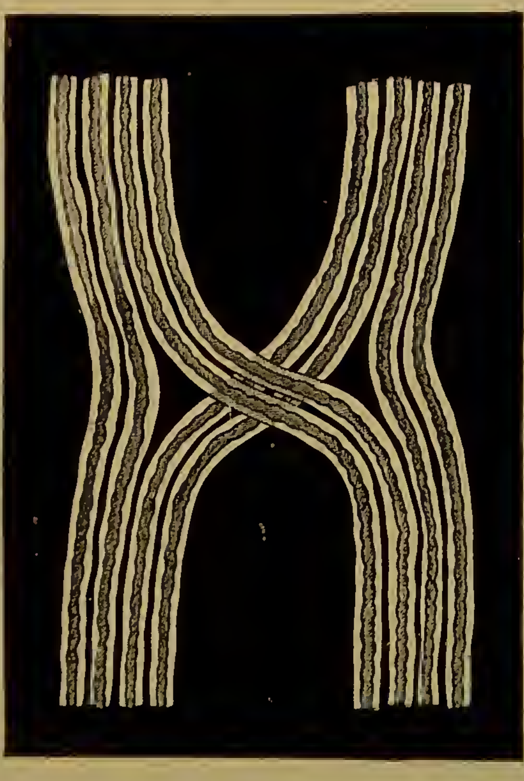


Fig. 62.—Connection between the bundles in a nerve. (Dalton.)

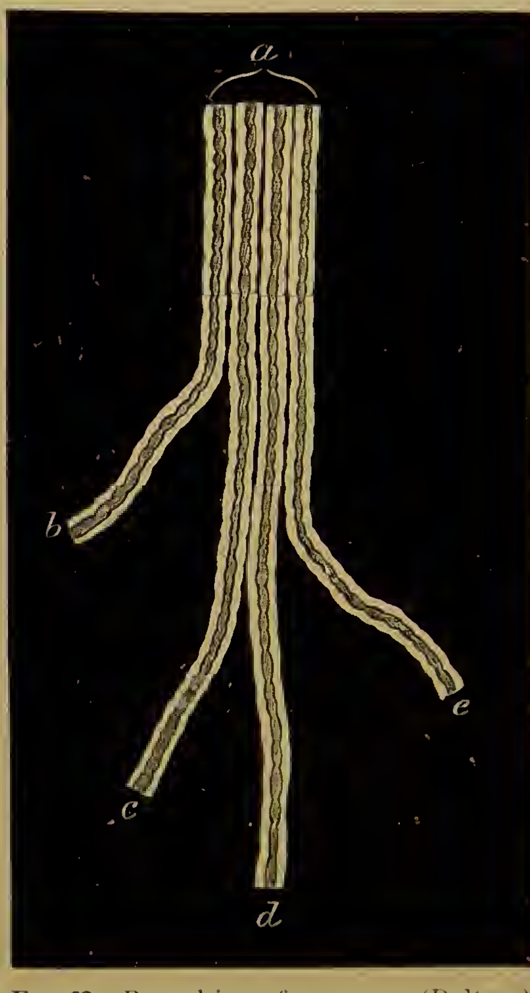


Fig. 63.—Branching of a nerve. (Dalton.)

from centre to periphery, there is never any coalescence between them. In the branching of nerves the same rule is observed: a funiculus lets some of its fibres switch off at the side or separates them into substantially equal parts, but the fibres themselves remain undivided (Fig. 63). The larger vessels of a nerve course in its sheath, and the capillaries are arranged in long meshes between the fibres. The epineurium is also supplied with nerves, called *nervi nervorum* ("the nerves of the nerves").

The origin of nerves varies with their function. Those which convey impulses from the centre to the periphery, called *efferent nerves* (meaning "carrying from"), grow outward from nerve-cells in the centre; while those which convey impressions from the periphery to the centre, called *afferent* (meaning "carrying to") or sensory nerves, grow inward from nerve-cells in organs of special sense or in

ganglia. These fibres branch within the nerve-centre, and send their ultimate twigs among the cells, but do not unite with them.

Ganglia ("knots") are bunches of various sizes occurring in the course of nerves. They are made up of nerve-cells and their coverings, massed upon and between the fibres of nerves (Fig. 64). Each cell of a ganglion has one or more axis-cylinder processes, which are prolonged into nerve-fibres. The ganglion is clothed with areolar tissue, which sends trabeculæ through it in every direction.

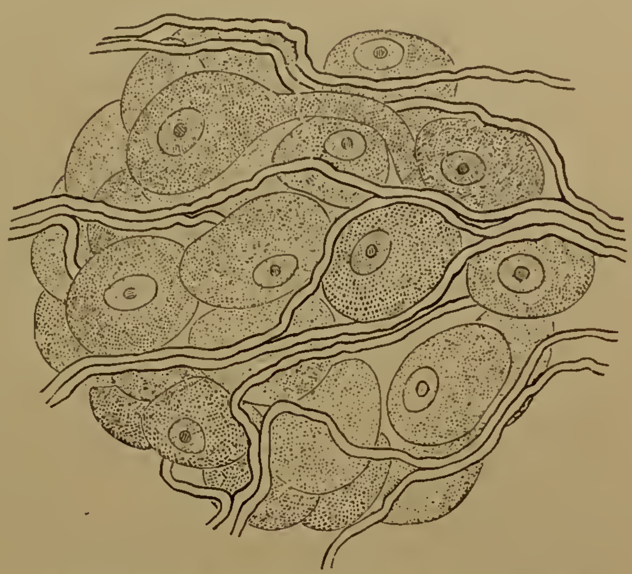


Fig. 64.—Arrangement of nerve-cells and nerve-fibres in a ganglion. (Dalton.)

Before coming to their peripheral division many medullated nerves lose their white substance; but others retain it during several stages of branching, and in these last the division takes place at nodes. After the disappearance of the medullary sheath the primitive sheath continues for a variable distance.

Afferent (sensory) *nerves* have various peripheral terminations. Some of them end in cells, others in special organs, as tactile corpuscles, end-bulbs, and Pacinian bodies. These will be described in the chapter devoted to the organs of the senses. Certain afferent nerves end peripherally by the final separation of the axis-cylinder into its component fibrils, which run between the tissue-elements, and generally either end there or else penetrate the cells. The sensory nerve-endings in tendons are often suggestive of the ending of motor nerves of voluntary muscle, to be described presently. Close to the muscle proper a medullated fibre passes into the tendon, divides repeatedly, and the filaments of the axis-cylinder penetrate widely into the tendon.

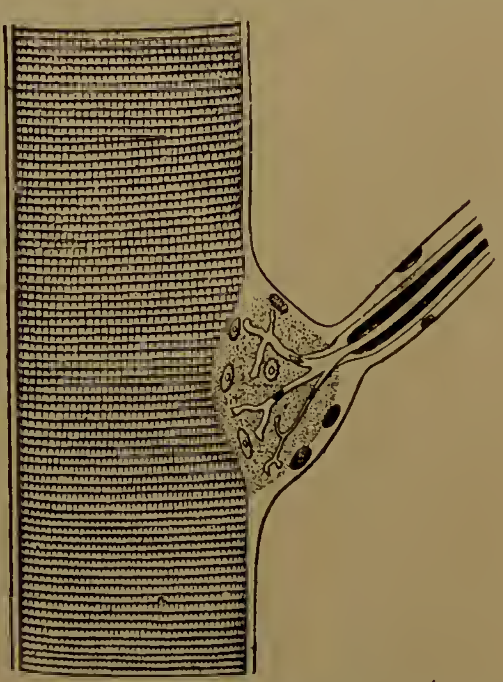


Fig. 65.—Motorial end-plate, the termination of a nerve in a fibre of cross-striped muscle. (Testut.)

Efferent nerves have different endings according to the variety of muscle to which they are distributed. In the case of the plain muscular tissue the fibrillæ of the nerve are brought close to the muscle-cells, after the nerve has formed a plexus in which ganglion-cells often occur. In cardiac muscle the nervous filaments come from a long-meshed plexus, and are applied to the contractile fibres. Finally, in striated muscle, after the formation of a close plexus, the nerve loses its white sheath, the axis-cylinder enters the muscle-fibre, and just beneath the sarcolemma splits up into its fibrillæ, which spread out in a thin mass of granular material in which nuclei are embedded. This is the *motorial end-plate* (Fig. 65).

MEMBRANES.

In its widest meaning the word "membrane" is used to designate any thin expansion of tissue, either simple or compound. Thus, we speak of the periosteum, the covering of bone, as a fibrous membrane; we call the layer of cells beneath the epithelium of free surfaces the basement membrane; and a structure composed largely of blood-vessels may be known as a vascular membrane. But in a restricted, although the commonest, sense the word is applied to a broad, sheet-like organ, with a free (unattached) surface, furnishing the covering of a

part or the lining of a cavity. With the latter signification the term is employed in this section.

The type upon which all of the members of the group are constructed consists of a foundation of white and yellow fibrous tissue, which is limited toward the free surface by a single layer of very thin, plate-like cells, and upon this last an epithelium (Fig. 66). The fibrous tissues are felted into a layer of variable thick-

FIG. 66.—A typical membrane in vertical section. (F. H. G.)

ness, strength, flexibility, and elasticity, according to the proportion and arrangement of its ingredients, and is called the *corium* ("leather"). The lamella of flattened cells surmounting this is really a part of the corium, for it consists merely of cells of the white fibrous tissue, greatly attenuated and adhering to each other at their edges. It is termed the *basement membrane.* Finally comes the *epithelium*, which presents upon the free surface, and may be either simple or stratified in numberless layers.

In most cases the attached surface of the membrane is connected with the underlying structures by areolar tissue, abundant or scanty, which permits some gliding of the membrane on the subjacent parts. This areolar tissue is called subserous, submucous, subcutaneous, and so on, according to the kind of membrane under which it lies. The line between it and the corium of the membrane is not exactly determinable, as a rule, the two structures being made of precisely the same materials, differing only in their mode of arrangement, and gradually shading from one into the other. When the membrane is peeled off from the areolar tissue its under surface is flocculent, on account of the attachment of bundles of the fibrous tissues of the latter. In the areolar tissue course the larger vessels and nerves of the region, sending their branches to, or receiving their radicles from, the corium.

There are four classes of membranes:

1. Serous Membranes.
2. Synovial Membranes.
3. Mucous Membranes.
4. Cutaneous Membrane.

SEROUS MEMBRANES.

Of all the membranes, the serous (*membranæ serosæ*) are the simplest—the nearest the type which has been described. They are always moist with a fluid very like blood-serum, and from this fact they derive their name. They are thin and transparent, permitting a view of the immediately subjacent parts, fairly strong, considering their delicacy, and somewhat elastic. With a single exception, which obtains in all females, but never in males, the serous membranes are shut sacs; that is to say, they have no opening by which they communicate with the surface of the body (Fig. 67). In the simplest of them this condition is so plain as to be easily understood; in the most complicated it is not especially difficult to demonstrate, even though the form of the membrane

FIG. 67.—Diagram showing arrangement of a serous membrane. The broken line represents the membrane lining the closed cavity. (F. H. G.)

suggests but remotely that of a sac. In those which are manifestly bag-like, and which furnish a complete or partial coating to internal organs, two parts are recognized—that which is attached to the viscus, and that which is fastened to the walls of the cavity in which the organ is contained. The former is called the *visceral layer*, the latter the *parietal* ("on the wall") or *reflected portion*. The relations of parts will be easily comprehended by reference to Fig. 68.

The diagram represents a viscus pushing one wall of the serous sac inward, thus making this portion serve as a tunic for the organ; consequently, this is the visceral part. The other portion of the sac lines the wall of the cavity in which the viscus now is enclosed, and is, therefore, the parietal part. It is not asserted that this is the precise way in which the viscera procure their serous coat; but the condition which exists is such as would obtain if this procedure were actual. For the sake of clearness in the diagram, a cavity is represented between the epithelial surface of the visceral layer and that of the parietal layer; but, as a matter of fact, the two layers are in actual contact, and the serous cavity, of which mention is often made, is not real, but virtual.

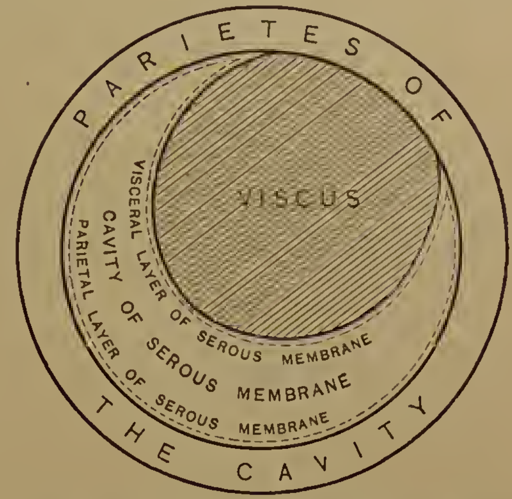


FIG. 68.—Diagram showing that when a viscus encroaches upon the space of a cavity, it still remains outside of the serous membrane, which gives it an external tunic while continuing to line the cavity. (F. H. G.)

Serous membranes present many folds, which connect viscera with each other or with the walls of a cavity, or simply project into a cavity and return on themselves, forming a tassel or an apron. A serous membrane may line a fibrous bag, and be reflected over the surface of a contained viscus, and in such case is denominated a *fibro-serous membrane*.

The *corium* is thin, but contains blood-vessels, lymph-vessels, and lymphoid and adipose tissues. The lymphatics are especially abundant. The nervous supply is small and is sympathetic in origin.

The *epithelium* (Fig. 69) is always single and flattened, the cells having irregular, notched edges and fitting accurately together, except that, at intervals, little apertures are found, some of which are the beginnings of lymph-vessels, and from this fact are named *stomata*, from the Greek word for "mouth;" and others are filled with processes from cells in the corium, and hence are called *pseudo-stomata* ("false mouths"). The true stomata are distinguished by a little boundary of cells, much smaller than those furnishing the general surface. The demonstration of their immediate connection with lymph-vessels led to the belief that serous membranes are only expansions of lymphatics, and, consequently, are to be regarded as belonging to the lymphatic system. Their physiological performance and their behavior in disease support this theory.

FIG. 69.—Part of free surface of a serous membrane, showing the flattened epithelial cells and the stomata.

The *epithelial surface* is particularly smooth and glistening, and thus the gliding of opposing portions is accomplished with very slight friction, which is still further reduced by the presence of the thin fluid constantly secreted by the cells. This fluid, which lubricates the membrane, is normally present in so small an amount that it merely moistens the surface. Just as fast as it is formed it is withdrawn by the lymphatics through the stomata. But, in disease, when the equilibrium between secretion and absorption is so disturbed that the lymphatics do not carry the fluid away as rapidly as the cells manufacture it, an accumulation occurs, the parietal layer is pushed away from the visceral by the intervening liquid, and in this way the virtual cavity is converted into a real one.

Serous membranes may be divided into tolerably distinct classes, as follows:

1. Serous membranes proper.
2. The lining membrane of the vascular system.
3. The lining membrane of certain cavities in sustentacular tissues.
4. The lining membrane of the cavity of the cerebro-spinal axis.

1. Serous Membranes Proper.

Under this head are included the various membranes which result from the division of the original serous membrane lining the thoracico-abdominal cavity (Fig. 70). These are derived from the single sac by constriction, the thoracic first

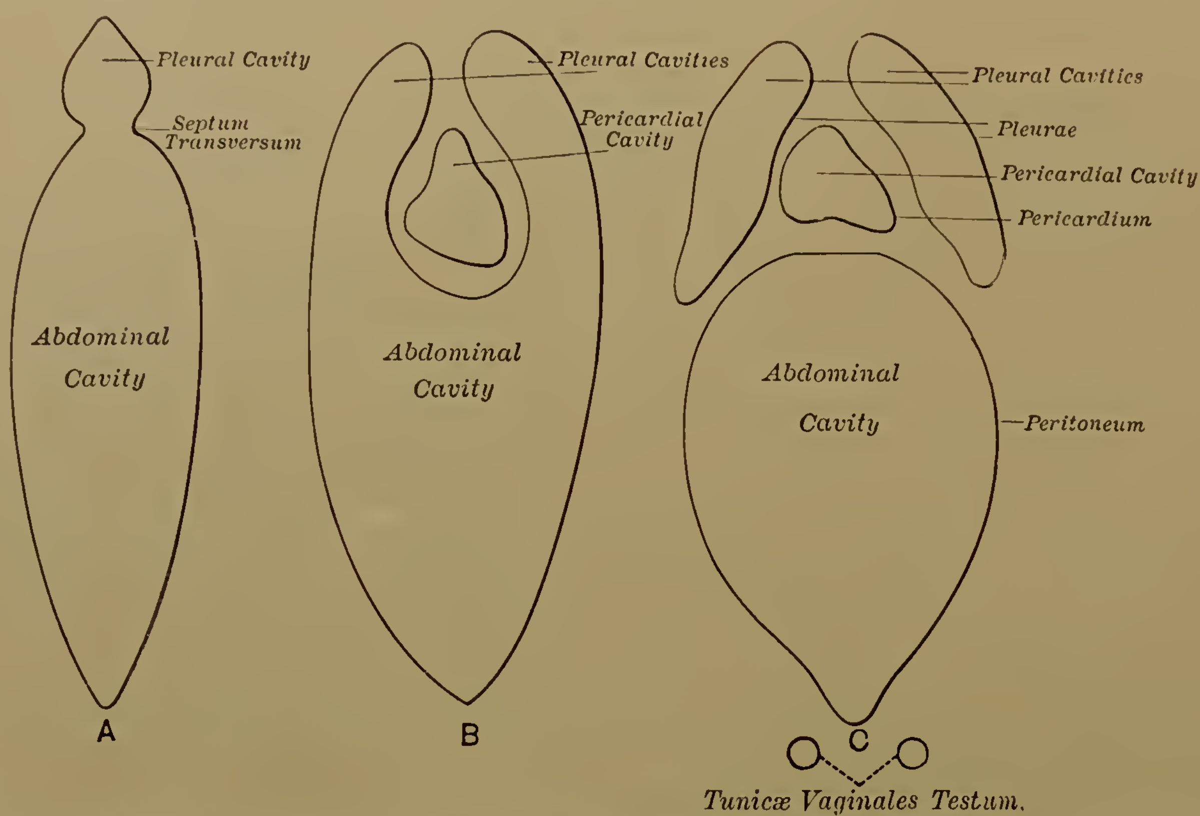


FIG. 70.—Diagram showing formation of several serous sacs from the one original sac. (After Gegenbauer.)

being separated from the abdominal, and then subdivisions of each of these making three distinct sacs of the upper grand division—the two pleuræ and the pericardium—and three of the lower grand division—the peritoneum and the two vaginal tunics. They are called serous membranes *proper*, because they present, to an extent which the others do not, the features which have been mentioned as characterizing this class of structures. The pleuræ cover the lungs and line the portions of the thoracic cavity which contain them; the pericardium stands in a similar relation to the heart; the peritoneum lines the abdominal cavity and clothes its contained viscera; and the vaginal tunics perform a like service for the two chambers of the scrotum and the organs (the testicles) which are lodged in it. These serous membranes will be treated of in detail in connection with the organs to which they are respectively related.

2. The Lining Membrane of the Vascular System.

This is the internal coat of the heart and vessels, known also as the *tunica intima.* It bears a close resemblance to the proper serous membranes in structure and appearance. Its power of forming a fluid like that of the great serous sacs is not to be doubted, but is not demonstrable, as the fluid must mingle with the current of blood or lymph as soon as it is formed. One at all acquainted with the circumstances favoring the coagulation of the blood, and the necessity of having it flow freely through the microscopic tubes which we call capillaries, would feel warranted in the declaration that no other membrane than a serous would be practicable as a lining to the blood-vessels and lymphatics. If a mucous membrane were employed for the purpose, the small vessels would

speedily become clogged with its thick and slimy secretion; and the thinnest and most delicate cutaneous membrane would obviously be too thick and coarse to permit the transudation necessary for the nutrition of the tissues. Only a serous membrane with its almost frictionless surface and its watery secretion could possibly meet the requirements of the case.

The details of structure of the tunica intima will be presented in connection with the description of the heart, blood-vessels, and lymphatics, respectively.

3. The Lining Membrane of Certain Cavities in Sustentacular Tissues.

The most conspicuous illustration of this form of serous membrane is found in the internal ear. Around the greater part of the membranous labyrinth, which is the essential portion of the organ of hearing, and between it and the bone in which it is lodged, is a considerable space, lined with serous membrane and filled with a watery fluid, which is called perilymph. Another example is found between the back of the eyeball and the bed of fat upon which it reposes. It is called the capsule of Tenon, and is a shut sac, with a visceral layer upon the globe of the eye and a parietal layer attached to the postjacent adipose tissue. It permits free movements of the eye in the orbit with the least possible friction. In character and function it closely resembles the proper serous membranes.

4. The Lining Membrane of the Cavity of the Cerebro-spinal Axis.

The brain and spinal cord are hollow organs. Their cavities are lined with a delicate membrane, serous in character, its epithelium being in embryonic life ciliated, and its secretion thin and watery. The membrane is known as the *endyma* ("garment") or *ependyma*. It will be described in the chapter on the Cerebro-spinal Axis.

SYNOVIAL MEMBRANES.

By certain authorities the synovial membranes (*membranæ synoviales*) are classed with the serous, and there are some good arguments in favor of this association. But, while these membranes have no communication with the surface, and have the same order of function as the serous membranes, there are such differences as to justify a separation of the one from the other. The group of synovial membranes with which surgeons have most to do are not shut sacs, although each forms a part of the wall of a closed cavity; they have a different lining from serous membranes; their secretion is not serous; and they are not associated with the viscera. Therefore, they are here treated by themselves.

The synovial membranes form a part or the whole of the enclosure of certain cavities, which are associated with the osseous framework or the muscular system, or both; and the service which they render is the lubrication of parts which glide upon each other.

A synovial membrane is composed of fibrous tissue, having on its free surface an imperfect covering of cells (Fig. 71), and thus affording the great exception to the rule that free surfaces are completely clothed with cells. These cells are of no regular shape, are branched, and are gathered into little patches, which are scattered over the surface, leaving considerable areas upon which no cellular structure appears. The cells are often called *epithelioid*, which means "like epithelium." Their secretion is a glairy fluid, which smears the entire free surface of the membrane, and is called *synovia*, from its resemblance to the white of egg.

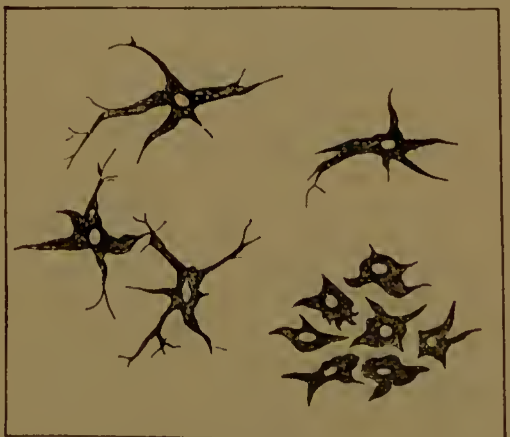


FIG. 71.—Synovial membrane—free surface, showing imperfect covering of cells.

Synovial membranes are divided into the following groups:
1. Articular.
2. Vaginal.
3. Bursal.

1. Articular Synovial Membranes.

These occur in those articulations of the bony skeleton wherein two surfaces move upon each other. The bones concerned in such a joint are covered on the surfaces, which enter into the composition of the articulation, with a crust of cartilage, whose free surface is very smooth and hard. The bones are held together by strong bands of white fibrous tissue—the ligaments—which encapsulate the expanded ends of the bones, forming hollow cylinders, which bound the joint. The inner surface of a capsular ligament is covered with a synovial membrane, which is reflected from it a little way upon the margin of each of the cartilages. Thus, the synovial membrane is a short tube with its edges turned inward. The arrangement of the parts will be seen in Fig. 72.

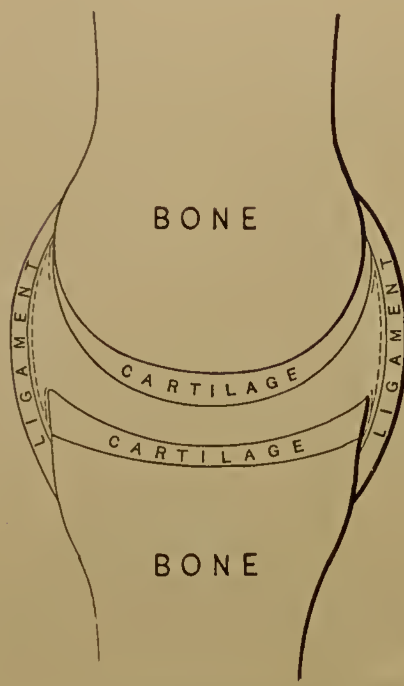


FIG. 72.—Diagram of articular synovial membrane. The cartilages are represented as drawn apart for the sake of clearness. The synovial membrane is shown by a broken line. (F. H. G.)

If, as sometimes occurs, a ligament or a tendon passes across or through the joint-cavity, the synovial membrane ensheaths it. Occasionally the membrane exhibits folds, which cross the cavity or hang into it like fringes, and perhaps contain some adipose tissue. In all cases the synovia secreted by the membrane lubricates the cartilages and other structures, which present a free surface in the joint.

2. Vaginal Synovial Membranes.

These are so named from *vagina*, "a sheath," and are also known as *synovial sheaths*. They are found in situations where the tendons of muscles run over bones, to which they are bound down by strong, fibrous bands. The bone in these cases is grooved, and the fibrous tissue bridges over the gutter, thus making a

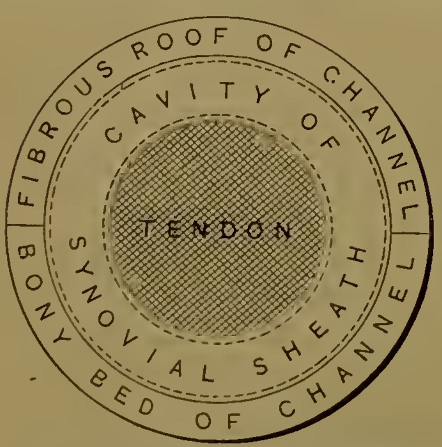


FIG. 73.—Diagram of a vaginal synovial membrane in cross-section. The membrane is shown by the broken lines. A space is left between the tendon and channel-wall for the sake of clearness. (F. H. G.)

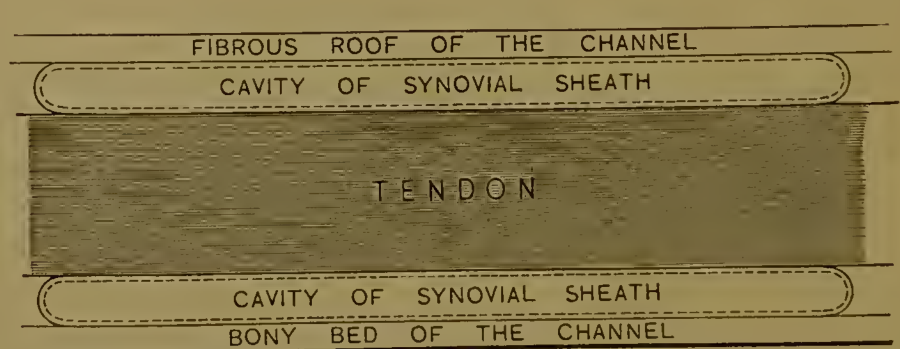


FIG. 74.—Diagram of a vaginal synovial membrane in longitudinal section. Compare with Fig. 74. (F. H. G.)

very strong, fibro-osseous canal, through which a tendon passes to its destination. The synovial membrane is arranged in the form of a tubular sheath, one portion lining the canal, the other investing the enclosed tendon, as will be seen in Figs. 73 and 74.

In the movements of the tendon friction is reduced to its lowest terms by the lubricating agency of the synovia.

3. Bursal Synovial Membranes.

Other names for these structures are *synovial bursæ* ("synovial purses"), *bursæ mucosæ* ("mucous purses"), and *vesicular synovial membranes*. A synovial bursa is a little bag of fibrous tissue, lined with synovial membrane, and placed between parts which move upon each other, as two muscles, two tendons, a muscle or tendon and a bone, the skin and a bone. The sac is connected with surrounding parts by areolar tissue, and the opposite sides of its internal surface are in contact, and kept moist with synovia. Some of these membranes are developed from spaces of areolar tissue by closure of connection with surrounding spaces, and condensation of the contiguous fasciculi of the tissue.

MUCOUS MEMBRANES.

The serous and synovial membranes line closed sacs; the mucous membranes (*membranæ mucosæ*) line passages and cavities which have a direct communication with the outer surface of the body. Indeed, from the physiological point of view, the parts which are covered by them are external, for they are regarded as inversions of the integument—portions of the outer investment tucked in and modified, but never lacking continuity with it.

There are two separate sets of mucous membranes—the gastro-pulmonary and the genito-urinary. Each of these consists of a continuous membrane, which lines two series of organs, and varies in many respects according to the organ of which it forms a part. The *gastro-pulmonary mucous membrane* (Fig. 75) furnishes a free surface for the alimentary and respiratory systems, and gets its name from a principal organ of each—the stomach and the lung. The *alimentary part* of it begins at the lips and passes through the mouth, the middle and lowest parts of the pharynx, the gullet, stomach, small and large intestines, and anal canal, and then comes to the skin-surface. In its course it sends offsets to the ducts of the salivary

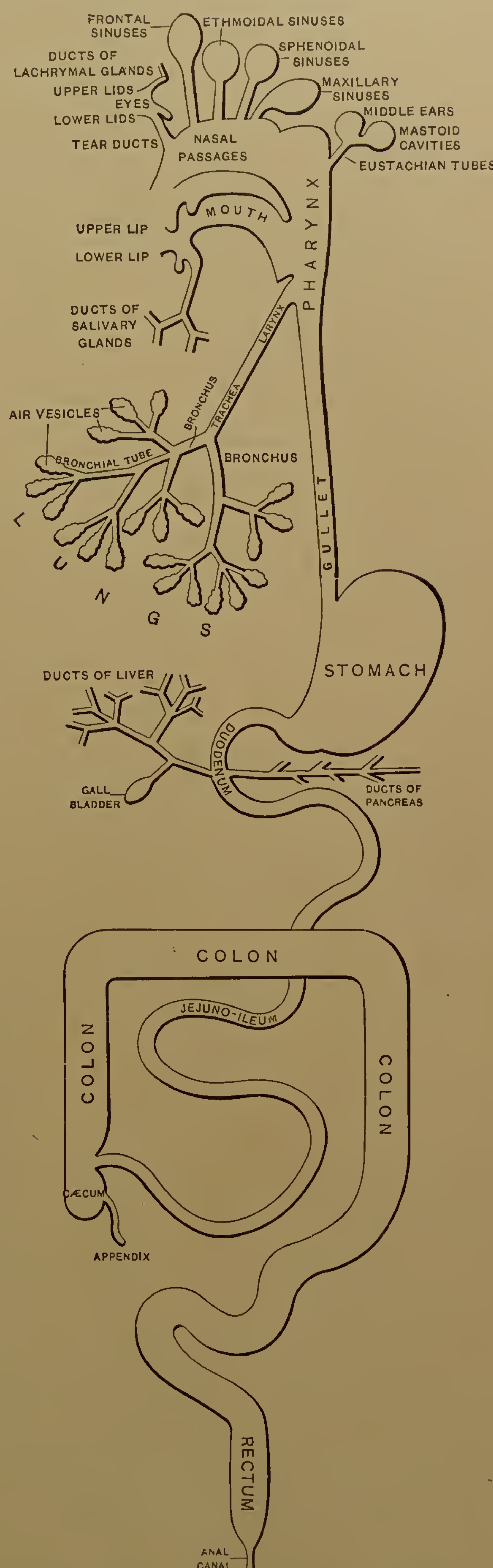


Fig. 75.—Diagram of the gastro-pulmonary mucous membrane, showing the continuity of all its parts. (F. H. G.)

glands, of the pancreas, and of the liver, to the gall-bladder, and to the vermiform appendix. The *respiratory portion* begins in the nostrils, and passes through the entire pharynx, the larynx, trachea, bronchi, and bronchial tubes, ending in the air-vesicles of the lungs. From the nasal cavities it gives prolongations to the inner surfaces of the eyelids and the front of the eyeballs, and to the chambers in the frontal, ethmoid, sphenoid, and upper-jaw bones; and from the pharynx it runs through tubes to the drums of the ears and the cavities of the mastoid portion of the temporal bones. The *genito-urinary mucous membrane* lines the genital and urinary tracts, as its name implies. The portion which forms a part of the male reproductive organs (Fig. 76) leaves its junction with the skin at the distal open-

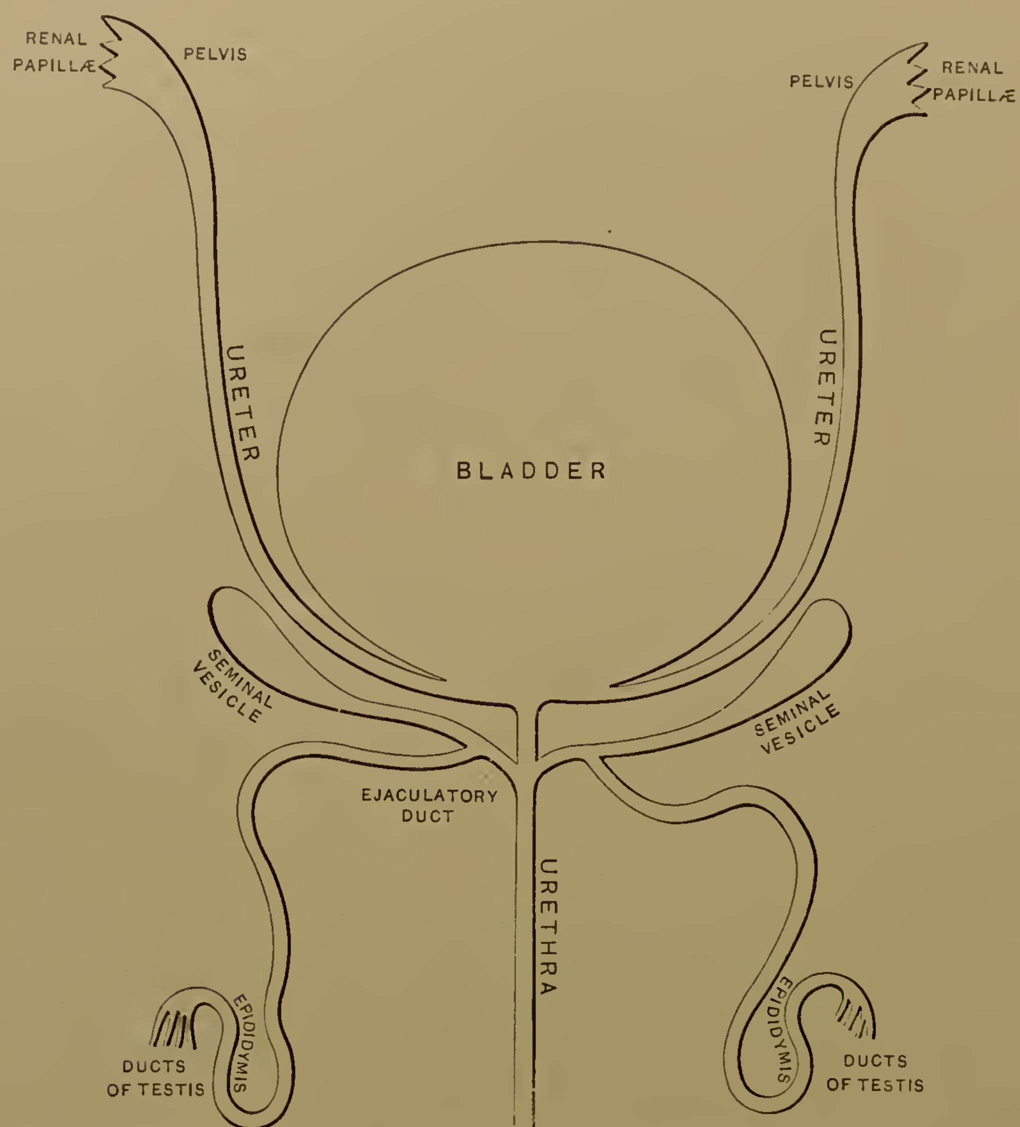


FIG. 76.—Diagram of male genito-urinary mucous membrane, showing continuity of all its parts. (F. H. G.)

ing of the penis, and is traced through the urethra to within an inch of its proximal end, where it enters the male womb and switches off on each side into the ejaculatory duct, from which it sends one prolongation to the seminal vesicle and a second to the vas deferens, and through this last runs to the epididymis and the ducts of the testicle. It sends offsets to the ducts of the suburethral glands and to those of the prostate. In the female the mucosa of the genital tract (Fig. 77) begins at the vulva, goes through the vagina, the uterus, and the two Fallopian tubes, at the free extremities of which it is continuous with the serous membrane lining the abdominal cavity. Offsets from it line the ducts of the vulvo-vaginal glands. In both sexes the *urinary mucous membrane* lines the urethra, bladder, and ureters, ending at the papillæ of the kidney.

The variations in the character of the mucous membrane in different parts are very great, and changes are extremely abrupt at several points, while in other cases the modifications are effected very gradually. The *corium* (Fig. 79) is generally much thicker than in serous and synovial membranes. It contains a comparatively small proportion of yellow fibrous tissue. When it is largely occupied by follicular glands, the ordinary fibrous tissue is to a considerable extent replaced

by adenoid-reticular, in whose meshes are entangled lymphoid cells, thus constituting a diffuse lymphatic tissue. Usually the corium is bounded toward the free surface by a basement membrane, and deeply by a thin layer of plain muscular tissue, which is named *muscularis mucosæ* ("the muscular [coat] of the mucous

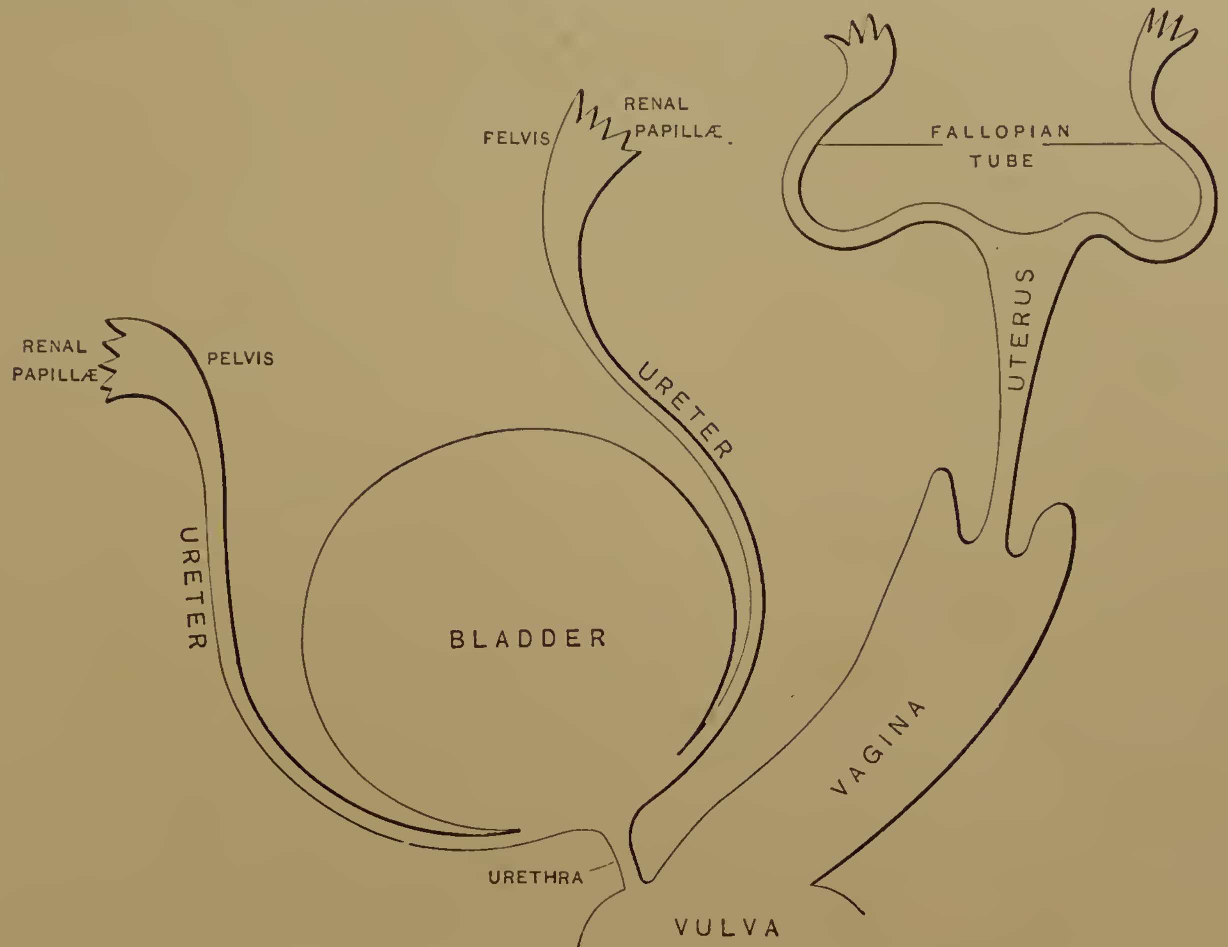


FIG. 77.—Diagram of female genito-urinary mucous membrane, showing continuity of all its parts. (F. H. G.)

[membrane]"). The *epithelium* is the one element in the membrane which is never wanting; but there are only a few cases and very limited areas in which it is the sole representative, the covering of the cornea being the most conspicuous.

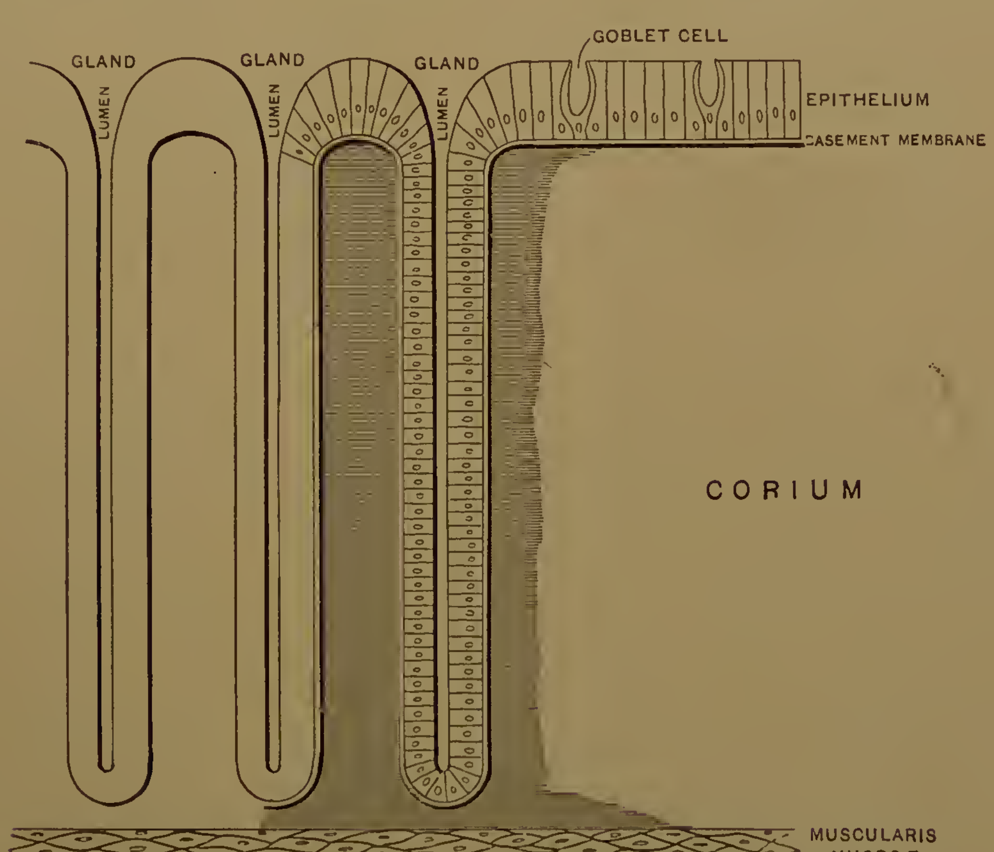


FIG. 78.—Diagram of mucous membrane in vertical section. (F. H. G.)

The epithelium may be single or stratified, of any possible shape, and with or without cilia. The membrane derives its name from the glairy fluid, *mucus*, which always covers it. This secretion is protective, and is abundant in propor-

tion to the amount of irritation to which the membrane is subjected. Where the epithelial coat is columnar and single, the mucus is furnished very largely by the goblet-cells of the epithelium; but, as these chalices are a modification of columnar cells, they are not found where the epithelium is flat; and in such cases all of the mucus comes from distinct glands, which devote themselves to this work.

Mucous membrane is generally connected with subjacent parts by areolar tissue; but exceptionally this is not present, and then the membrane is attached directly. This occurs only in cases where the passage or cavity which the membrane lines is not subject to distention, as in the nose, where the corium is fastened to the bone. In general, the areolar layer beneath mucous membrane is very abundant, and the usefulness of this arrangement appears when we consider that the corium has but little elastic tissue in its composition, and in many cases is pervaded by glandular structures, which would be injured by the stretching of the membrane. As a rule, the cavities and tubes which are lined with mucous membrane are liable to great changes of size, owing to their intermittent occupation by solids and fluids to such an extent as to distend them. Between the periods of distention are times of collapse. If the membrane were elastic, like serous membrane, and had no delicate glands embedded in its substance, it could be stretched within a large range without harm, and would return to its state of relaxation on removal of the distorting force; and in such circumstances it would need but a moderate areolar layer between it and the subjacent parts. As it is, the membrane when relaxed becomes more or less folded—thrown into shallow or deep wrinkles—and presents a series of ridges, called *rugæ*, which in tubes are arranged in line with the longitudinal axis of the organ (Fig. 79). When a

Fig. 79.—Diagram showing the folding of the mucous membrane in a collapsed tube. (F. H. G.)

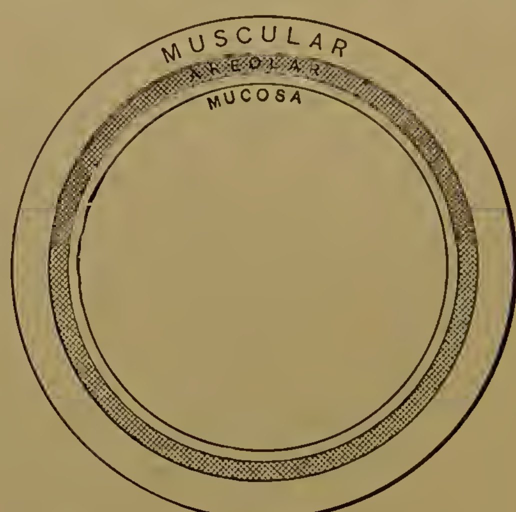


Fig. 80.—Diagram showing the effacement of the folds of mucous membrane and the compression of the areolar layer when the tube is distended. Compare with Fig. 80. (F. H. G.)

distending force is applied, as in the passage of a bolus of food through the gullet, or after a large dinner has been deposited in the stomach, these folds are effaced, the membrane becomes smoothed out, and presents an even surface (Fig. 80). This extensive change is rendered possible by the abundance of the submucous areolar coat, which is strong and elastic.

Mucous membrane is very vascular, the vessels for its supply running in the submucous areolar tissue, and sending minute branches into the corium above. Its nerve-supply varies greatly in different parts—some being extremely sensitive, others dull of feeling. As would be inferred from the amount of lymphoid tissue in the corium, its lymphatics are very abundant. The peculiarities of the mucous membrane of each part where it exists will be detailed in the description of the organs respectively concerned.

CUTANEOUS MEMBRANE.

By this term is indicated the membrane which furnishes the outer covering of the body, and is ordinarily called *skin*. It is a complex structure, and has

a variety of functions, among which is the distinguishing of impressions of touch. It will, therefore, be more appropriately considered with the organs of the senses.

GLANDS.

A gland is an organ, which abstracts from the blood certain materials and makes of them a new substance, which is then discharged into a cavity or upon a surface. In other words, a gland is a secreting organ, its process and its product both bearing the name of secretion. Simply constructed membranes, such as the serous, doubtless perform some secretory work; but it is always of a low order, and the resulting product is only slightly different from the materials of which it is composed. It would not be expected that the cells upon a plane surface, whose principal function is protective, and which are constantly subjected to hard usage on account of their exposed situation, would be able to do secretory work of any but the most primitive kind. It would be as reasonable to demand a high grade of work from an artisan stationed in the middle of a thoroughfare, where he would be jostled by every passer. Such a one needs freedom from interference, and withdraws from the bustle of the throng into a secluded retreat, where he has every facility for doing the most delicate and elaborate tasks. Nature acts in precisely this way in constructing an organ which is to make a secretion: a depression appears in a membrane—an inversion of the surface-structure takes place—and the cells, which are thus removed from the worries and dangers of the open and exposed locality, experience various changes. They become plumper and softer, their nuclei enlarge, and they develop a capacity for secretion, which their less favorably environed neighbors never emulate. The materials which they abstract from the blood are so wrought over that their original character is not suggested by the nature of the secretion of which they are the ingredients. The organ which accomplishes this thing is a true gland; and, as a rule, the more completely it is guarded from annoyances and interruptions, the more elaborate and valuable is its work.

The essential thing in a gland, as has already been intimated, is the *epithelial cell.* The forms of secreting cells are as varied as possible, but the tendency is to keep near the spherical type. Indeed, spheroidal epithelium is hardly to be looked for outside of glands.

The simplest form of a gland is the follicular, a mere dimple in the surface (Fig. 81, *A*). Enlargement of the embedded tube, without dilatation of its open-

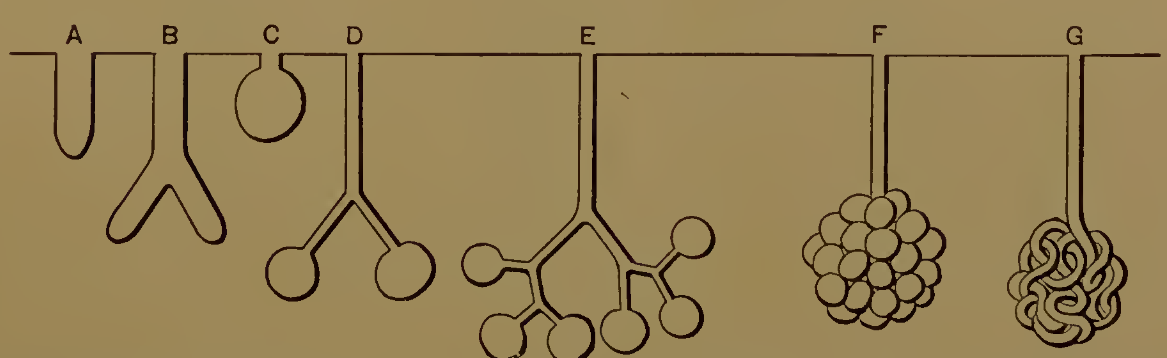


FIG. 81.—Diagram showing development of glands: *A*, a mere dimple in the surface; *B*, enlargement by division; *C*, enlargement by dilatation; *D*, a combination of *B* and *C*; *E*, a racemose gland; *F*, development of method of *E*; *G*, a single tube intricately coiled. (F. H. G.)

ing, makes a saccular or flask-shaped gland (Fig. 81, *C*). Branching of the lower parts changes a simple gland into a compound (Fig. 81, *B*), and what was previously the upper part of the secreting organ now becomes the duct of discharge, its epithelium losing its true glandular character, and becoming more like that upon the general surface. By repetition of these processes the gland becomes not only larger, but more complicated — fibrous or reticular tissue occupies the interstices, and affords mechanical support; muscular

tissue forms around the ducts; and in many ways elaboration goes on, until in some glands not a suggestion of the original type remains to casual observation. And yet, the parentage of the most intricately constructed gland can be traced back to the little inversion of the surface, which has been shown to be a simple follicular gland, and the structural principle is identical in the two.

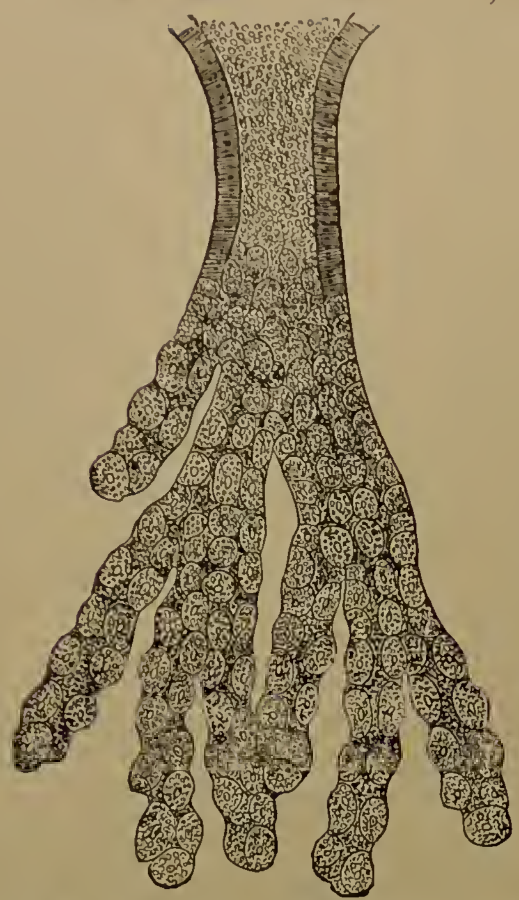


FIG. 82.—Compound tubular gland. The upper part is the duct; the lower is the secreting portion. (Kölliker.)

FIG. 83.—Compound racemose gland. The resemblance to a bunch of fruit is very marked. (Milne-Edwards.)

EMBRYOLOGY.

By J. P. McMURRICH.

At one period of its existence every vertebrate animal is represented by a single cell, from which the adult individual develops by its repeated division and by the functional and histological differentiation of the aggregate of cells so formed. The cell, however, which has the power of undergoing this development is one which results from the complete fusion of two distinct elements, likewise cells, one of which is termed the *ovum*, and represents the female element of reproduction, the other being the *spermatozoön*, the male element.

Spermatogenesis.

The male cell is formed in the testis, and, if a section of a seminiferous tubule be examined, an arrangement will be seen which is represented diagramatically in Fig. 84. The cells lining each tubule are arranged in several layers, the outermost

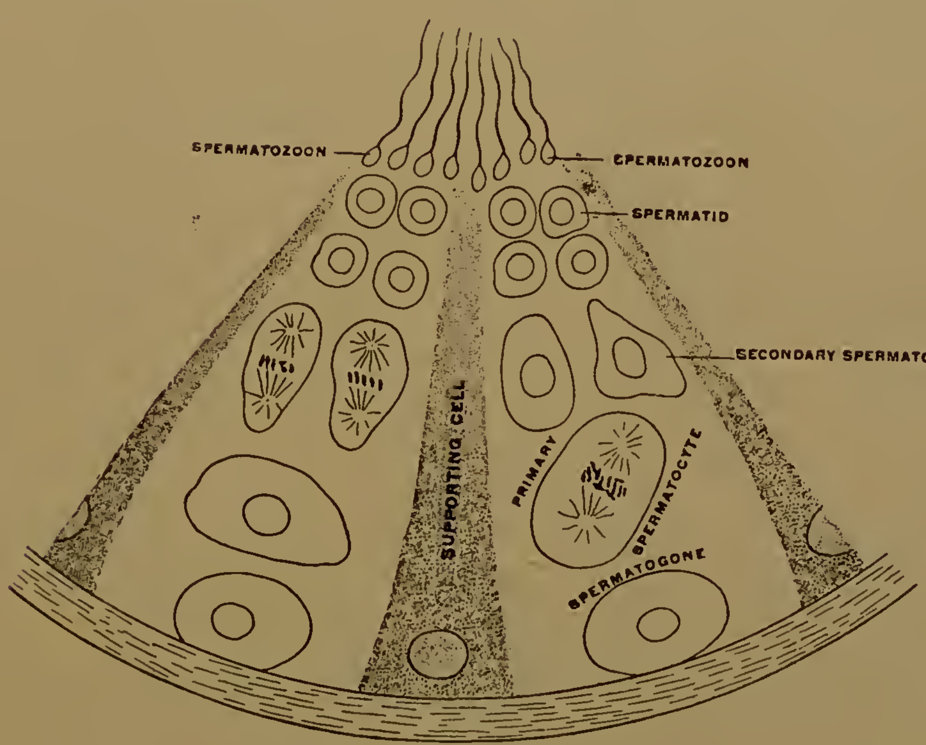


Fig. 84.—Development of spermatozoa.

layer being formed principally by a number of cells known as *spermatogones*. Each of these from time to time divides, one of the cells so produced persisting as a spermatogone, while the other becomes what is termed a *primary spermatocyte*. This cell later divides into two cells, each of which is a *secondary spermatocyte*, and these, undergoing a further division, give rise to cells termed *spermatids*. Thus, from each primary spermatocyte, by two divisions, four spermatids are developed, and each of these last becomes a *spermatozoön*. In addition to these various cells, others are to be found resting upon the basement membrane of the tubule, and extending through the various layers of the developing cells, the spermatozoa being grouped upon their inner ends. These are the *Sertoli cells*, or *supporting cells*, and they do not take any part in the formation of the spermato-

zoa, but, as their name indicates, serve for the support of the germ-cells, and probably assist in their nutrition.

The spermatozoa are the result of modification of the spermatids. Each of these latter is at first a round cell with a rather large nucleus, near which lies the *centrosome*. Gradually this cell elongates, the nucleus takes up a position near one extremity, an axial filament develops in the cell-body, the centrosome comes to lie behind the nucleus, and, as the final result, there is produced the mature spermatozoön, a body measuring in length about $\frac{1}{500}$ inch, and consisting of (*a*) a pyriform head composed of the nucleus of the original spermatid, surrounded by an exceedingly thin layer of protoplasm; (*b*) of a "middle piece," immediately behind the head, and representing probably the centrosome of the spermatid; (*c*) of the tail, derived from the cell-body of the spermatid, and composed of an axial filament surrounded by a sheath of protoplasm, somewhat variable in form, though usually simply cylindrical; and (*d*) of a terminal filament, which is the end portion of the axial filament.

Oögenesis.

The ovum, as it exists in the ovary, corresponds to the primary spermatocyte of the male, and must undergo certain changes ere it is ready for union with the spermatozoön.[1] When ready to burst from the Graafian follicle, the human *ovum* (Fig. 85) is a spherical cell about $\frac{1}{150}$ inch in diameter, enclosed within a membrane, the *zona radiata*, and containing a large *nucleus*, situated somewhat excentrically, while centrally there are a number of granules of *food-yolk*, a substance much more abundant in the ova of other mammals, such as the cat, and which forms the greater mass of the ovum of birds and reptiles. The maturation phenomena (Fig. 86) by a series of divisions convert the ovum into a structure homologous with a spermatid.

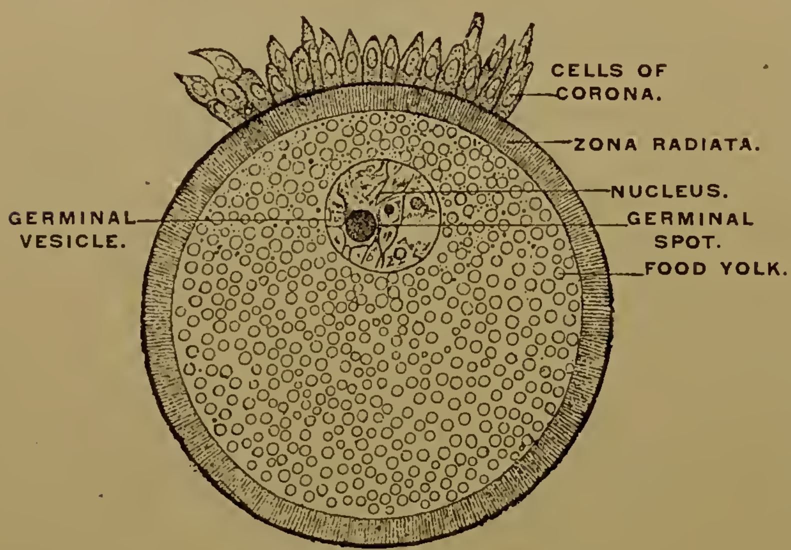


Fig. 85.—Ovum. (Waldeyer.)

At the first division (*A*, *B*, *C*) the *oöcyte*, as the ovum at this stage may be termed, divides into two cells, one of which is, however, very small and is termed a *polar globule*, while the other is practically as large as the original oöcyte. By a second division (*D*, *E*) a second polar globule is formed, and the nucleus then passes into the resting stage and moves toward the centre of the ovum (*F*). There are thus two maturation divisions, just as there are two divisions of the spermatocytes in spermatogenesis; and the polar globules are to be regarded as abortive ova, which take no further part in development, but degenerate.

After the extrusion of the polar globules the ovum is ready for union with the spermatozoön—a process which occurs probably, as a rule, in the upper part of the Fallopian tube. A spermatozoön penetrating the zona radiata is received into the substance of the ovum, and gradually passes centrally toward the ovum-nucleus. The tail of the spermatozoön is sooner or later absorbed; but the head—which, it will be remembered, represents the nucleus of the spermatid—and the middle piece pass on to come into close apposition, and finally to fuse, with the ovum-nucleus, the compound nucleus so produced soon becoming converted into a division spindle which inaugurates the segmentation of the ovum.

[1] Neither these changes nor the phenomena of fertilization have yet been observed in the human ovum. They have been observed, however, repeatedly in the ova of many of the lower animals, both vertebrate and invertebrate, and their general similarity in all cases makes the probability that they occur also in the human ovum almost a certainty.

It would seem from these phenomena that the essential feature of fertilization is the union of the nuclei of two cells, the small amount of protoplasm present in the head of the spermatozoön seeming to play little part in the process. Since both paternal and maternal characteristics may be inherited, it has been supposed

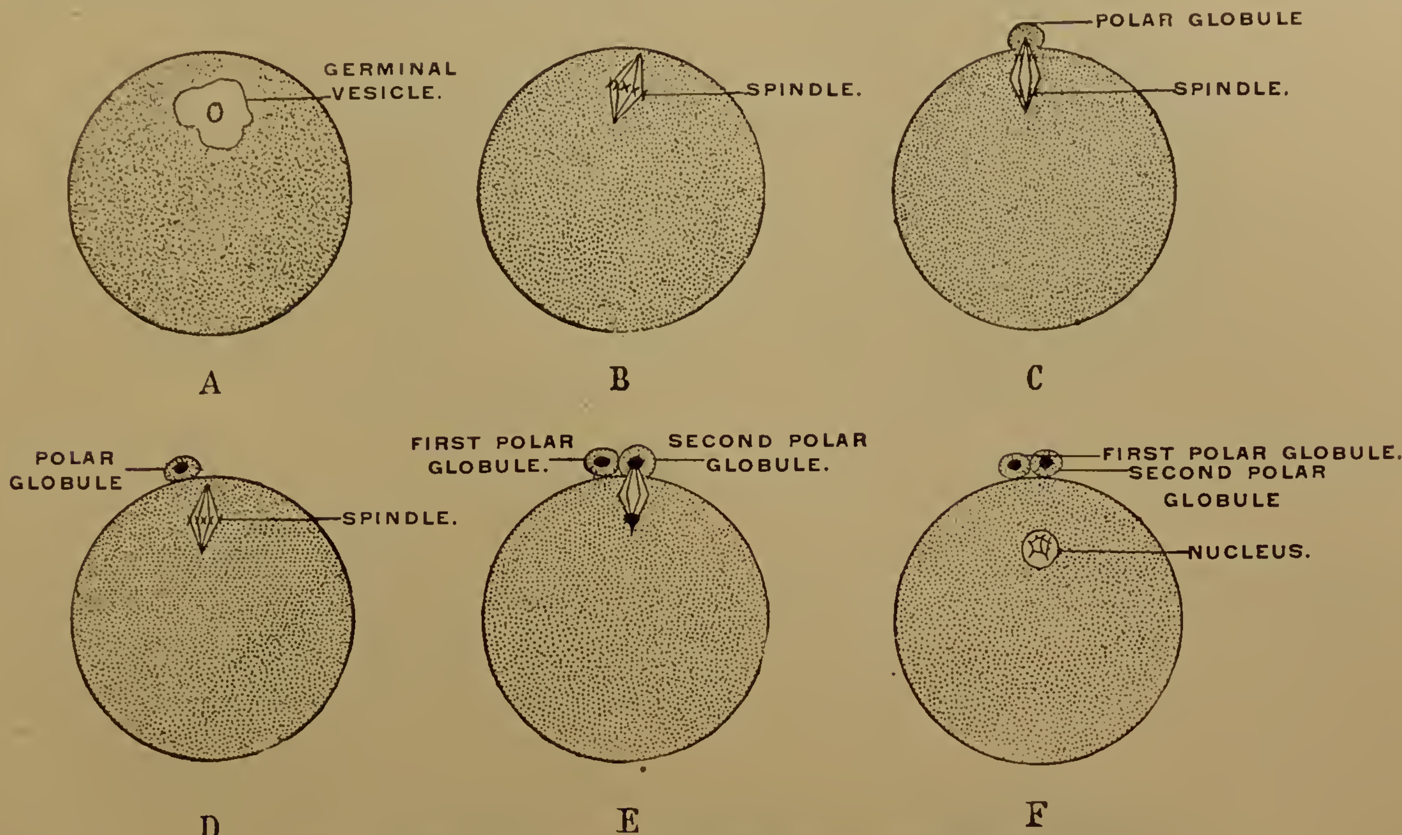


FIG. 86.—Diagram illustrating the phenomena of maturation. (Testut.)

that the nuclei must be the material bearers of heredity; and, since the characteristic substance of a nucleus is the chromatin, this has been regarded by many authors as the actual substance concerned in transmitting inherited peculiarities from the parent to the offspring.

The Early Stages of Development.

By segmentation is meant the conversion of the unicellular ovum into a mass of cells, a process which results from a series of divisions. The ovum first divides (Fig. 87) into two cells (*a*), each of these again dividing, so that four cells are

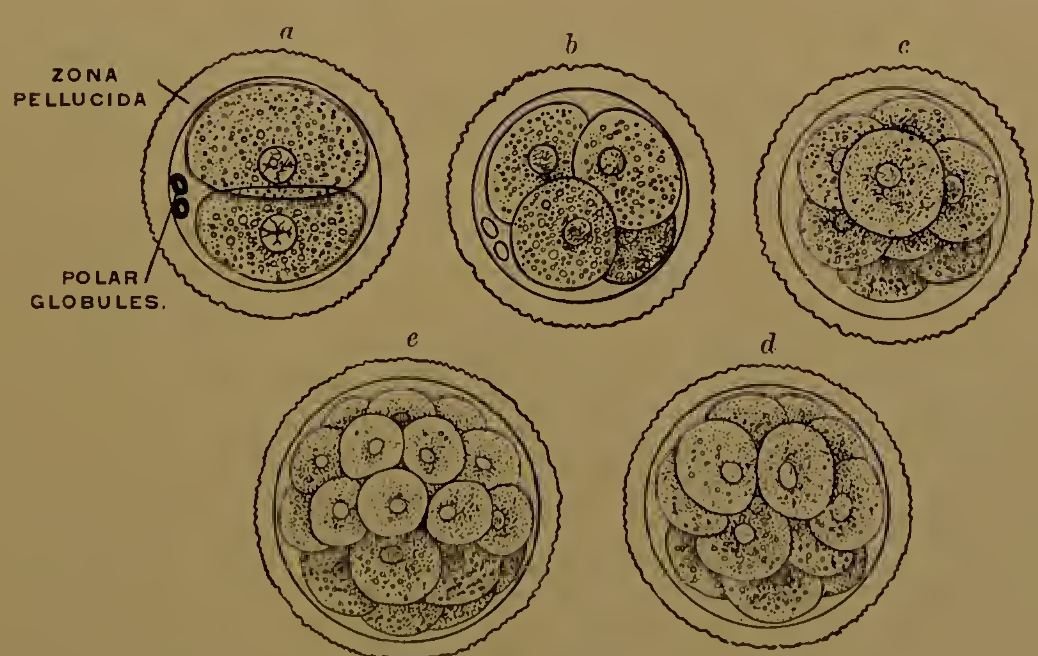


FIG. 87.—Segmentation of the ovum. (After van Beneden.)

formed (*b*), and, the divisions continuing (*c*, *d*), a solid mass of cells, termed a *morula*, is produced (*e*). A section through such a mass (Fig. 88, *A*) will show that it is composed of an outer layer of somewhat flattened cells enclosing a

number of distinctly granular cells. At first no cavity exists in the centre of the morula, but soon the outer cells become in large part forced away from the inner ones by the imbibition of a fluid supplied by the walls of the uterus, and what is

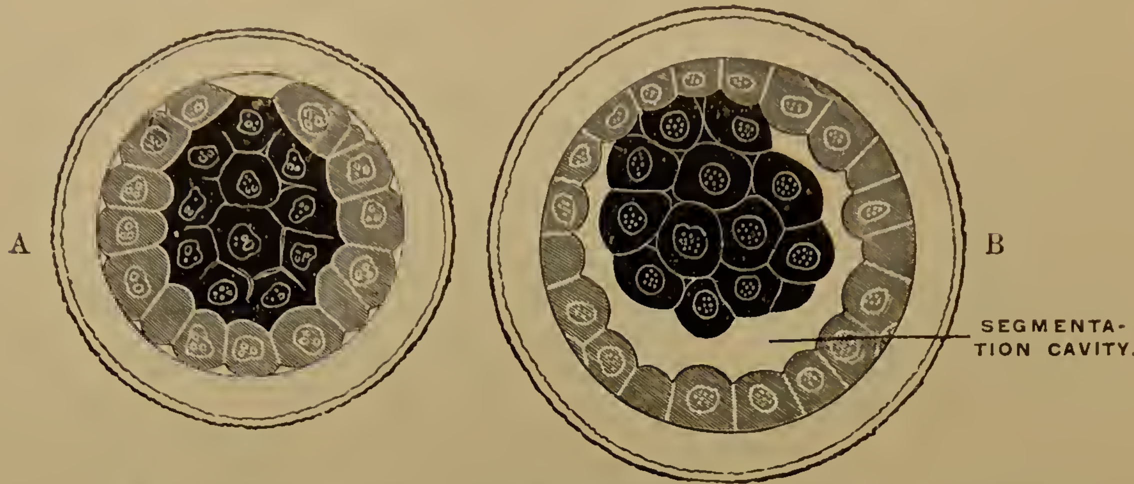


FIG. 88.—Sectional views of ovum, after segmentation. (After van Beneden.)

termed a *segmentation-cavity* is formed (Fig. 88, *B*). The morula is thus converted into a hollow vesicle, termed the *embryonic vesicle*, whose wall is composed of a single layer of cells, except at one region, where what were the inner cells of the morula form a lenticular thickening (Fig. 89).

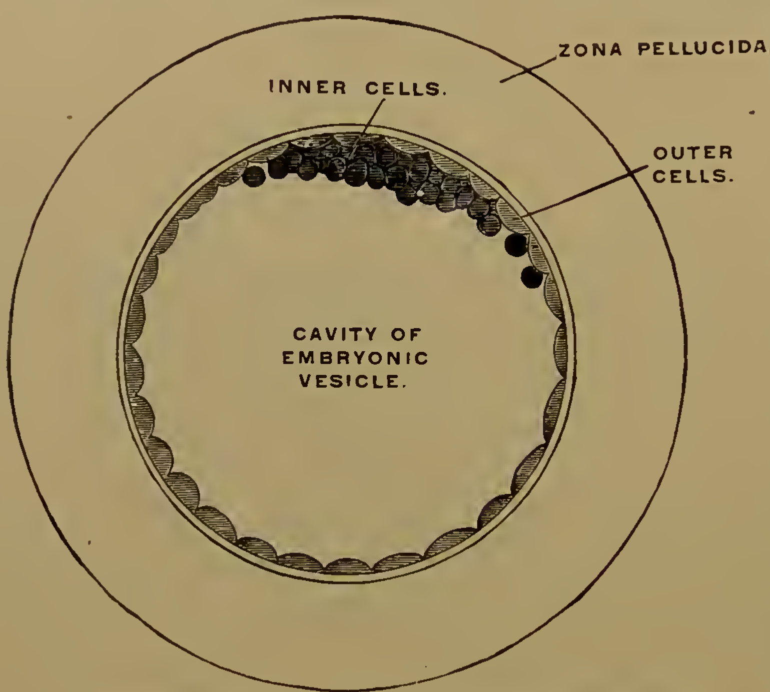


FIG. 89.—Embryonic vesicle. (After van Beneden.)

Later, the innermost cells of this thickening become somewhat flattened and arrange themselves in a distinct layer, which extends out in all directions and eventually completely encloses the segmentation-cavity, which now is known as the *yolk-sac*, or *umbilical vesicle*, the layer of cells enclosing it being termed the *endoderm* (Fig. 90, *A*). While this process is taking place a cavity, known as the *amniotic cavity*, makes its appearance in the outer part of the lenticular thickening, and the cells which form the floor of the cavity become columnar and constitute a layer termed the *ectoderm*, while the cells between this and the endoderm remain irregular in shape and form the *mesoderm* (Fig. 90, *A*). These three layers are known as the *germ-layers*, and it is by the differentiation of their cells that the various tissues and organs of the embryo are developed, each layer giving rise to certain definite structures. To the portions of the germ-layers which lie in the floor of the amniotic cavity the term *embryonic disc* is applied, since it is from this portion alone that the embryo proper will form, the remainder of the embryonic vesicle giving rise to accessory structures necessary during embryonic and fœtal life, but discarded at birth.

The outer layer of cells which forms the wall of the embryonic vesicle has, in the meantime, increased in thickness; its inner cells, which are continuous at the edges of the embryonic disc with the embryonic mesoderm, may be regarded as forming the extra-embryonic portion of that layer. This mesoderm now splits parallel with the surface of the vesicle into two layers, one of which, the *somatopleure*, adheres to the wall of the vesicle, while the other, the *splanchnopleure*, is more closely associated with the endoderm (Fig. 90, *B*). The narrow cleft between these two mesodermic layers rapidly increases in size with the growth of the vesicle, and becomes an extensive cavity known as the extra-embryonic *body-*

cavity, or *cœlom*, into which there projects the yolk-sac, enclosed within the endoderm and splanchnopleure, and united to the wall of the vesicle by a mass of meso-

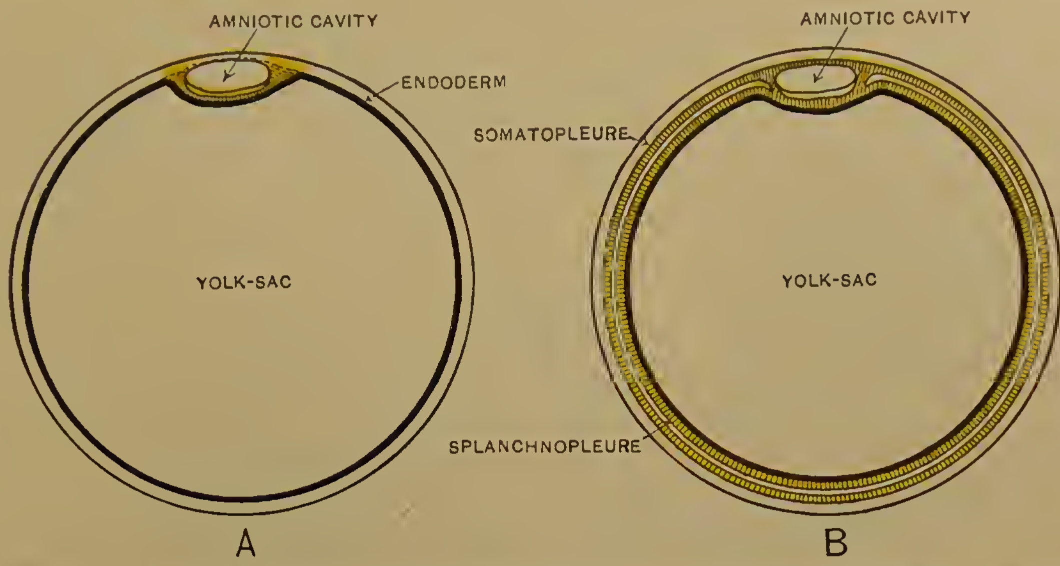


FIG. 90.—Diagrams of sections through the human embryonic vesicle in early stages. The ectoderm is white, mesoderm yellow, and endoderm black.

derm in which the amniotic cavity and embryonic disc are imbedded (Fig. 91).[1]

In succeeding stages of development the embryonic disc and with it the amniotic cavity enlarges, the growth being largely in the direction in which the

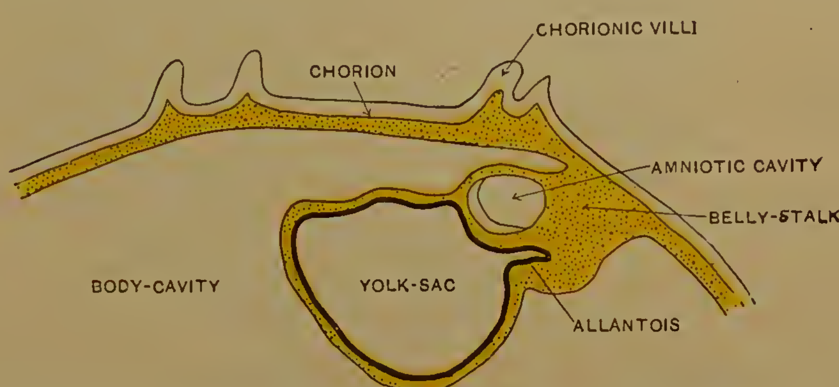


FIG. 91.—Diagram of section through the portion of an early human embryonic vesicle which contains the embryo. (After Graf Spee.)

head end of the embryo will later develop. The portion of the mesoderm which lies behind the amniotic cavity and embryónic disc remains accordingly unaltered, and increasing in thickness and length forms a pedicle, the *belly-stalk*, united to the embryo near its hind end, and attaching it to the inner surface of the embryonic vesicle (Fig. 96). Immediately in front of it on the embryonic disc a dark line extends some distance forward; it is formed by the fusion in this region of the three germ-layers, and is termed the *primitive streak* (Fig. 92). From its anterior end a narrow band of cells grows forward, displacing the original endoderm along the median line of the embryonic disc, and forming what is termed the *chorda endoderm*. Up to this stage, however, there has been no indication of a differentiation of definite organs; but now a groove appears in the median line of the embryonic disc, extending from the anterior end of the primitive streak almost to the front edge of the disc, and later the ectoderm on either side and in front of the groove rises up to form ridges or folds, which enclose the groove and are known as the medullary folds, the groove itself being termed the *medullary groove* (Fig. 92), the two together forming the first indications of the nervous system. Immediately beneath the medullary groove another groove appears in the chorda endoderm, the convexity of the groove being directed toward the floor of the

[1] This is practically the shape which the earliest human embryo at present known has reached. It is evident, therefore, that the various processes described above are hypothetical so far as their application to the human embryo is concerned, though they are known to occur in the ova of other mammals. It may also be noted that the account given above differs materially from that found at present in embryological text-books, but the structure of early human ova recently studied seems to demand some such previous processes as described.

medullary groove; its lips later unite, the cavity of the canal so formed becomes obliterated, and a solid rod, the *notochord,* lying beneath the central nervous system, is produced (Fig. 93).

The remainder of the chorda endoderm grows out on each side between the ectoderm and endoderm to form a plate of mesoderm, which displaces or unites with the mesoderm already present. The plates do not long remain simple, however, but become separated into two layers (Fig. 93), one of which becomes continuous with the extra-embryonic somatopleure and the other with the splanchnopleure. The cavity which separates these two layers is the embryonic cœlom, and is continuous with the corresponding extra-embryonic cavity. The splitting of the mesodermal plates does not, however, in the higher mammalia extend quite to the inner edge of each plate, but only to a longitudinal groove which has appeared, marking off a narrow portion of each plate immediately external to the median line of the body. This median band of mesoderm now becomes divided by a series of transverse constrictions into a number of oblong masses, which have been termed *protovertebræ,* or, better, *mesodermal somites* (Figs. 93 and 94), the tissue which lies beneath the groove separating these from the more lateral portions of the plates being termed the *intermediate cell-mass.* The formation of the somites begins in what will be the neck region of the embryo, and thence extends both forward and

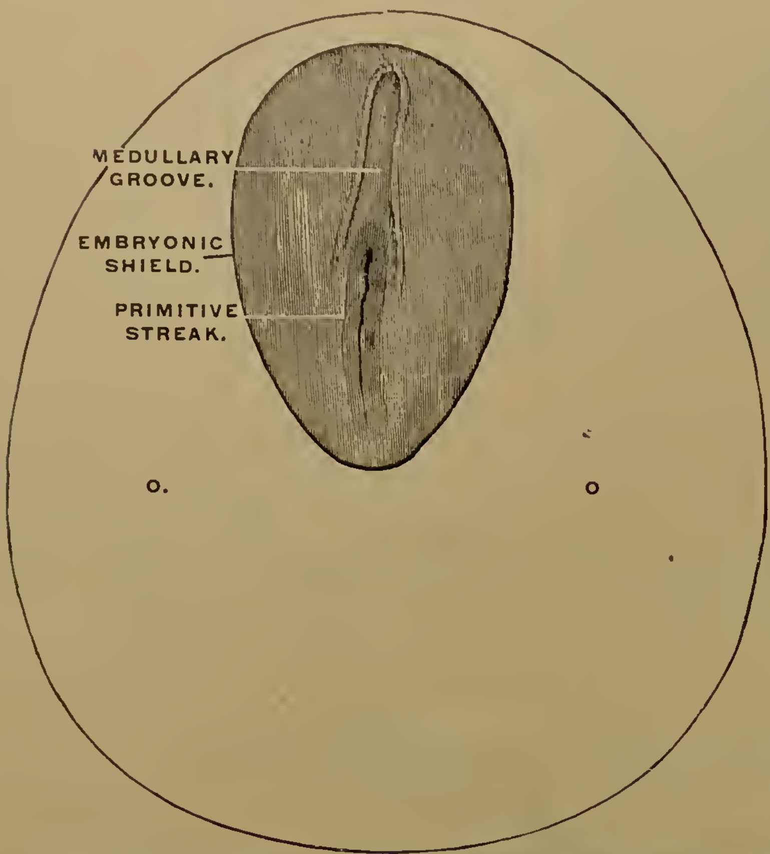


FIG. 92.—Formation of primitive streak and medullary groove. (Kölliker.)

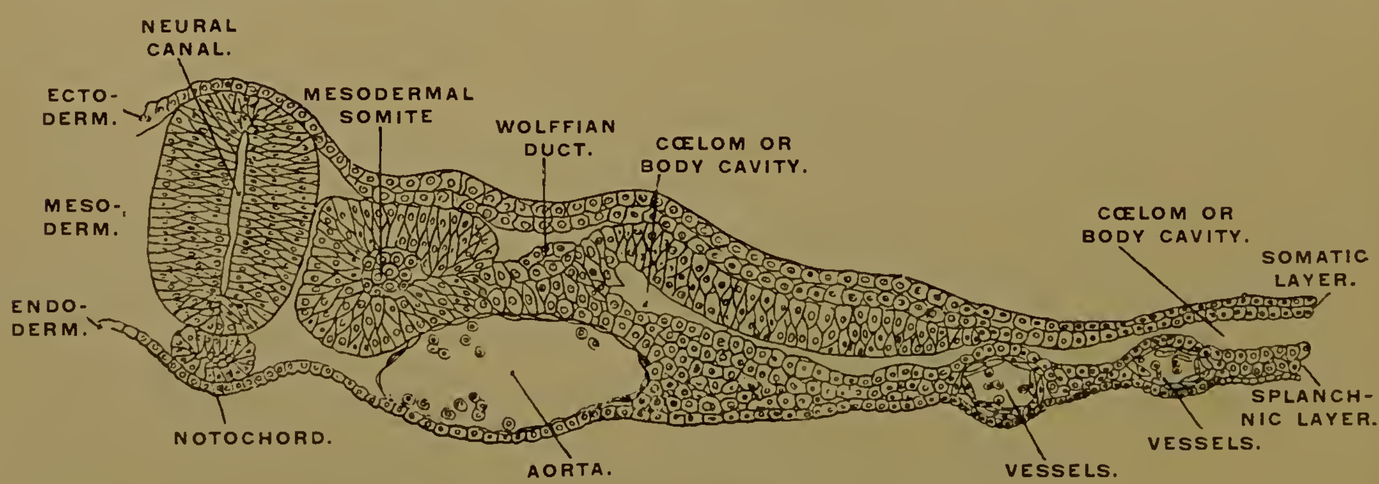


FIG. 93.—Transverse section through dorsal region of embryo.

backward until the median portions of the mesoderm of the trunk and neck regions of the body are divided into somites, indications of them also occurring in the head region.

As the result of these changes the embryonic disc has become differentiated into several areas. Along its median part is the central nervous system, the mesodermal somites, and the intermediate cell-masses, these forming the embryonic area proper; external to this is a region where the disc presents a somewhat transparent appearance, and this is termed the *area pellucida;* while the more peripheral portions are opaque and receive the name of the *area opaca.* In this last region extensive changes have been taking place in the mesoderm: some

of its cells arrange themselves so as to form a network of cords, into the substance of which fluid penetrates from the surrounding tissues, the cords being thus transformed into canals in which lie numerous cells. These canals are blood-vessels; the fluid which they contain becomes the plasma of the blood; the outermost cells of the original cords flatten and produce a thin wall for the vessels, while the more central cells group themselves into masses, which project here and there into the interior of the vessels from their walls, and are termed the *blood-islands.* An abundant network of blood-vessels traversing the area opaca is thus

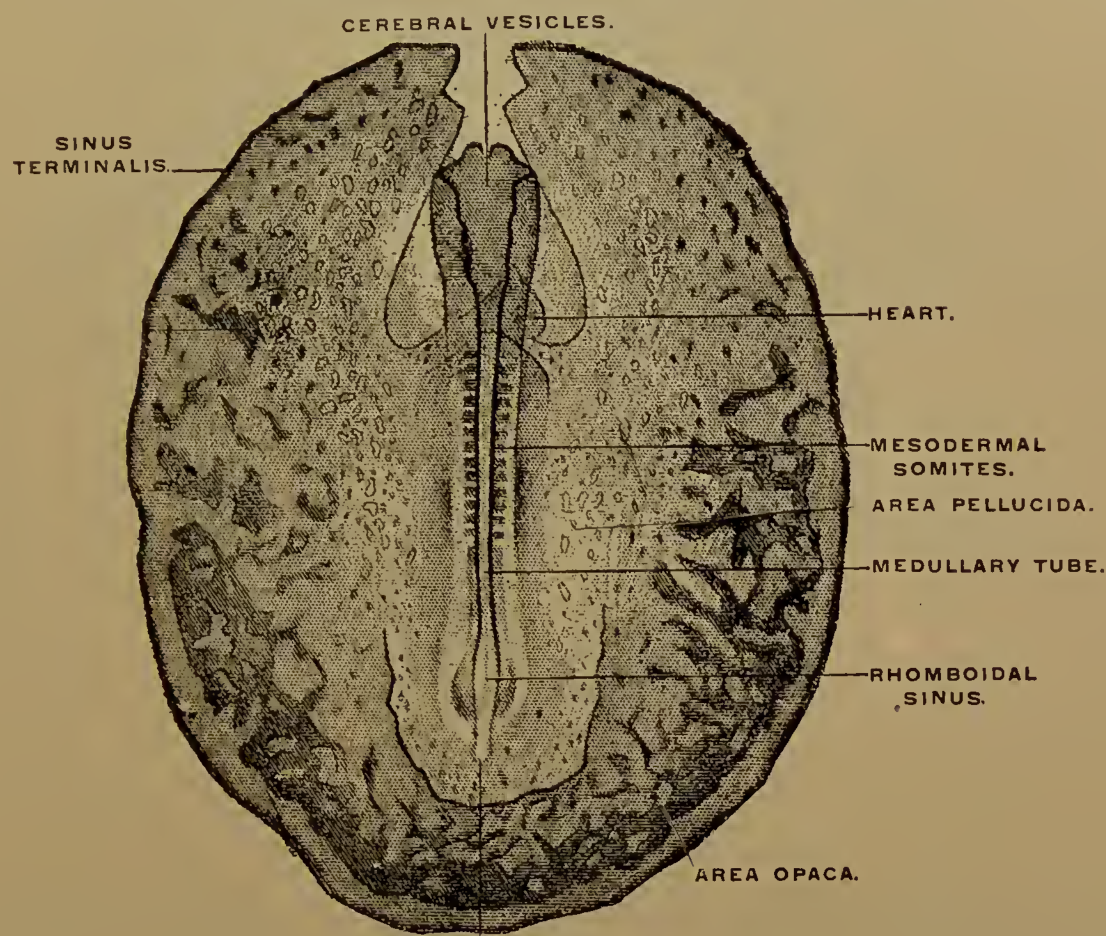


FIG. 94.—Development of somites. (Testut.)

formed, the intervals of the network being occupied by masses of unspecialized cells, which are termed *substance-islands,* and later give rise to embryonic connective tissue. Toward the periphery of the area opaca a circular blood-vessel, known as the *sinus terminalis,* is formed, marking the extreme periphery of the vascular region; and, though the area opaca may extend beyond this, the blood-vessels do not, and it is thus possible to divide the area opaca into a more central *area vasculosa* and a more peripheral area opaca proper. The formation of blood-vessels begins a little later in the area pellucida, and thence they grow in toward the body of the embryo.

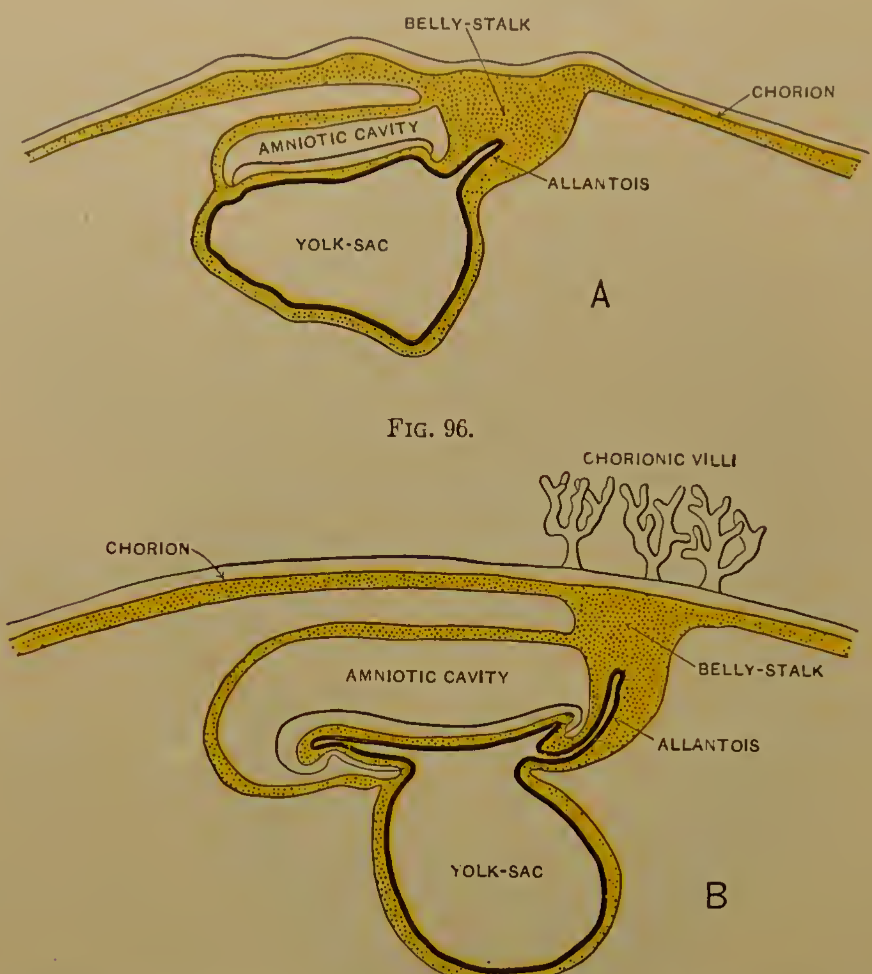
The Umbilical Cord and the Placenta.

The embryo during the early stages of its development forms a flat disc, which may be regarded as resting upon the surface of the yolk-sac, and forming the floor of the amniotic cavity, its ectoderm and somatopleure being continuous with the wall enclosing that cavity at the edges of the embryonic disc. At its hind end a thick pedicle, the belly-stalk, composed of mesoderm, unites it to the wall of the embryonic vesicle, which is now known as the *chorion,* and into the substance of the belly-stalk there projects a small diverticulum of the yolk-sac, which represents a rudimentary *allantois,* a structure largely developed in lower forms, in which it serves as an organ of respiration and secretion during embryonic life.

While the changes above described have been taking place the embryo has begun to constrict itself off from the yolk-sac by a tucking in, as it were, of its more peripheral portions, so that it gradually becomes transformed from a dis-

coidal to a cylindrical structure. The tucking in proceeds more rapidly from before backward than in other directions, and constricts the yolk-sac, converting it into a pear-shaped vesicle connected with the intestine of the embryo by a narrow stalk (Fig. 96). Eventually the tucking-in process results in the complete

Fig. 95.



Figs. 95 and 96.—Diagrams of sections through the human embryo in early stages of development. (Modified from Graf Spee.)

closure of the ventral surface of the embryo except over a small area, the *umbilicus,* through which the stalk of the yolk-sac and the belly-stalk pass. From the margins of this area the body-wall now becomes reflected outward, and encloses the two structures in a common investment, the cord so formed being known as the *umbilical cord* (Fig. 97). Since the edges of the embryonic disc are continuous with the wall of the amniotic cavity, this is carried around the embryo during the tucking-in process, and as the body-wall grows out over the stalk of the yolk-sac and belly-stalk the amnion is also carried out until its attachment to the embryo is at the outer end of the umbilical cord, and the embryo hangs suspended in a large amniotic cavity (Fig. 97). The mesoderm which the umbilical cord contains becomes converted into a peculiar jelly-like connective tissue, known as Wharton's jelly, in which are imbedded the rudimentary allantois and the yolk-sac, and in which the umbilical arteries pass out to the chorion, and the umbilical vein passes in to the embryo. Over the entire extent of the chorion numerous branched processes, termed *chorionic villi,* are developed; but the majority of these disappear later on, only those lying over the outer end of the umbilical cord persisting (Figs. 96 and 97). That portion of the chorion upon which the villi persist is termed the *chorion frondosum,* while that from which they disappear is the *chorion læve.* Into each villus a loop of the umbilical vessels passes, and the chorion frondosum forms the fœtal portion of the *placenta,* the organ by which the fœtal structures are brought into relation with the maternal (Fig. 97).

In the meantime important changes have taken place in the walls of the uterus. The mucous membrane lining it becomes greatly thickened, forming what is termed the *decidua vera,* and that portion of it which is in contact with the chorion frondosum becomes especially thick, and its blood-vessels dilate to

form wide sinuses into which the chorionic villi project, so that a ready osmotic interchange can take place between the maternal and fœtal bloods through the thin walls of the villi, and the nutrition, as well as the respiration and secretion of the embryo, can thus be carried on. To this portion of the uterine mucosa which forms the maternal portion of the placenta the name *decidua serotina* is

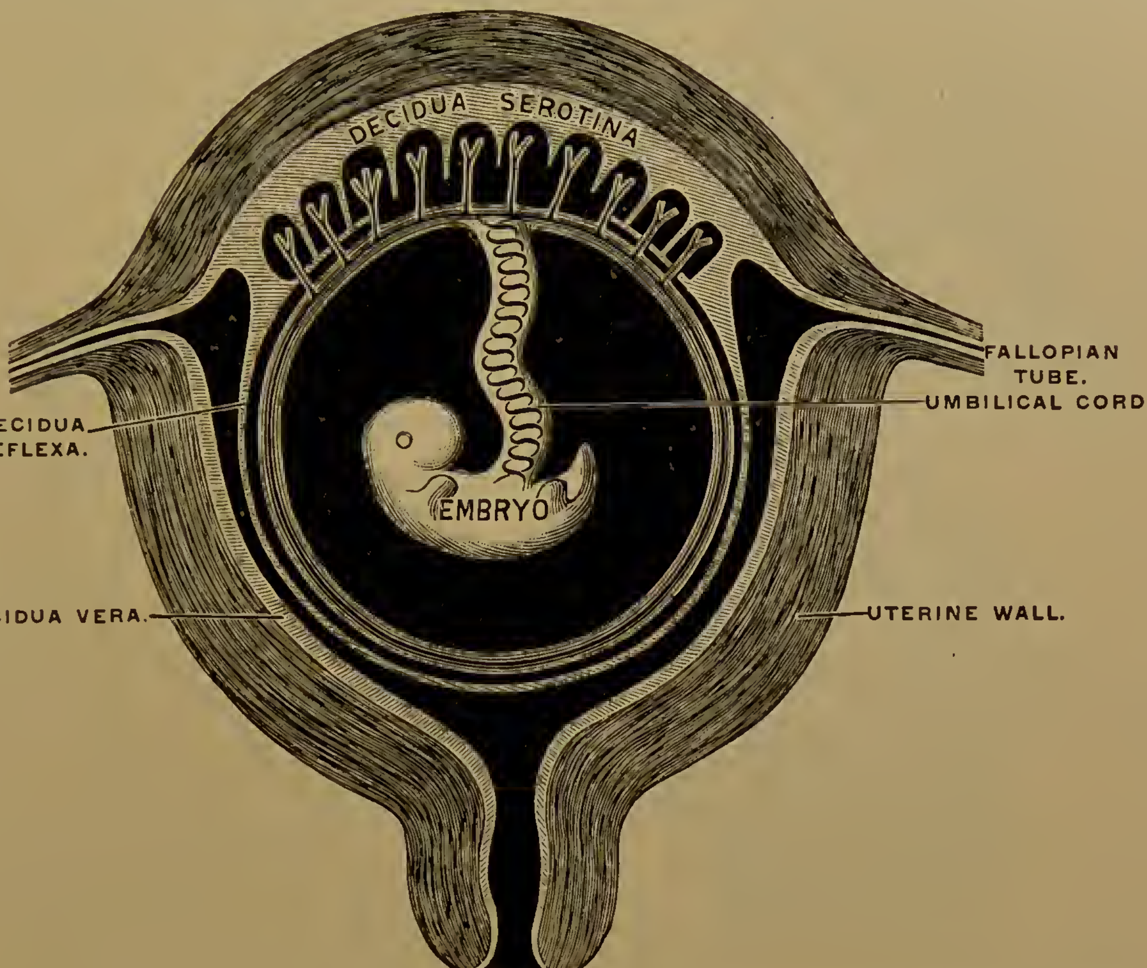


FIG. 97.—Diagram of gravid uterus, showing formation of deciduæ and placenta. (Testut.)

applied. Finally, when the ovum reaches the uterus after fertilization, it imbeds itself in the substance of the mucosa, and the portion of that membrane which thus covers the ovum becomes later the *decidua reflexa* (Fig. 97). At birth the amnion is ruptured, allowing the escape of the amniotic fluid, and after the birth of the fœtus the amnion and placenta, together with other deciduæ which separate from the walls of the uterus, are cast off, forming what is known as the *after-birth*.

To return now to the embryo proper. At its first separation from the embryonic shield it is practically straight, but a bend soon makes itself apparent in what will later be the region of the mid-brain, the fore-brain being bent ventrally until it is almost at a right angle to the rest of the body; and, at about the same time, a linear depression directed dorso-ventrally appears on each side of the neck region, and gradually deepens until it almost unites with the cavity of the digestive tract. This depression is known as a *branchial cleft*, and is succeeded by three others which develop successively from before backward (Fig. 98). When the second cleft is developed a second flexure of the embryo appears, the posterior portion of the body being bent dorsally. This flexure, however, is of short duration, and leaves no permanent trace of its existence; but, when the third branchial cleft forms, a third and more prominent flexure appears, this time a ventral flexure situated in the neck region, and, as the dorsal portion of the body also becomes curved in the same direction, the embryo seems to be coiled upon itself. Soon after the development of this neck-flexure the limbs make their appearance as simple paired, bud-like outgrowths from the sides of the body, and, as development proceeds, they increase in size, and rudiments of the fingers and toes appear. Gradually in later stages

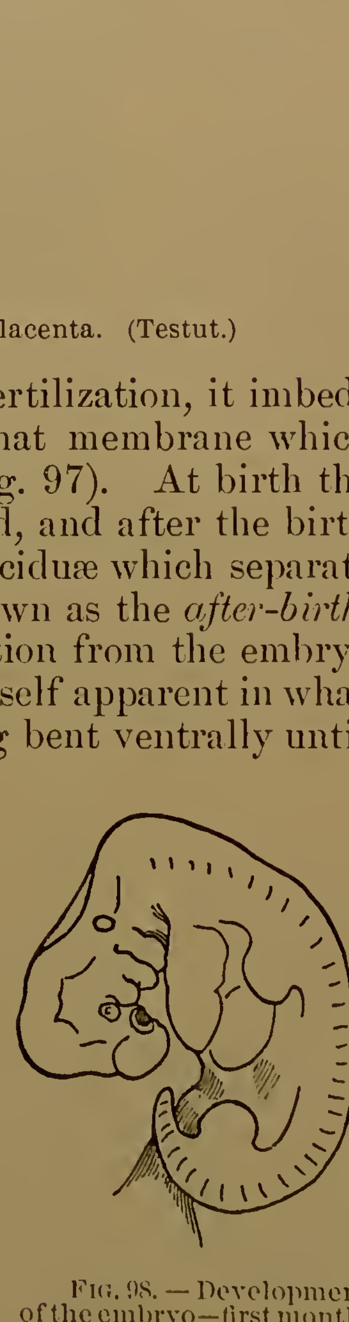


FIG. 98.—Development of the embryo—first month. (His.)

the branchial clefts disappear or are modified into special structures not seen from the exterior, the features are gradually developed, the neck-flexure straightens out, and by about the third month of development the embryo has acquired a distinctly human appearance.

It will now, after this sketch of the formation of the embryo, be convenient to consider the development of the more important organs of the body, and these may be grouped according to the germ-layers from which they are principally formed. For convenience the development of the organs derived from the endoderm will first be considered.

ORGANS DERIVED FROM THE ENDODERM.

At the stage with which the description of the formation of the germ-layers ended the endoderm formed a tube closed at either end, and having connected with it two outgrowths, the umbilical stalk and the allantois. An examination of the surface of the embryo at this stage will show an irregular depression opposite the anterior end of the endodermal tube (Fig. 99). This depression is the *oral sinus*, or *stomodæum*, and it is bounded in front by the edge of a median fold of tissue known as the *fronto-nasal process*, while on either side is a >-shaped ridge, the anterior limb of each ridge being termed the *maxillary*, and the posterior the *mandibular process*. The thin partition which forms the floor of the oral sinus soon ruptures, and the endodermal tube is thus placed in communication with the exterior, its endoderm becoming continuous with the ectoderm of the sinus. Soon after the mouth is thus formed the two maxillary ridges, growing toward each other, meet with the fronto-nasal process, and, in the connective tissue which the two contain, the maxillary bones develop. From each of these bones a horizontal lamella grows inward, and meets with its fellow of the opposite side and with corresponding lamellæ from the palatine bones behind, and the hard palate is thus formed, separating the original mouth-cavity into an upper or nasal and a lower or oral portion, these two cavities communicating behind with the upper or pharyngeal part of the intestinal tube.

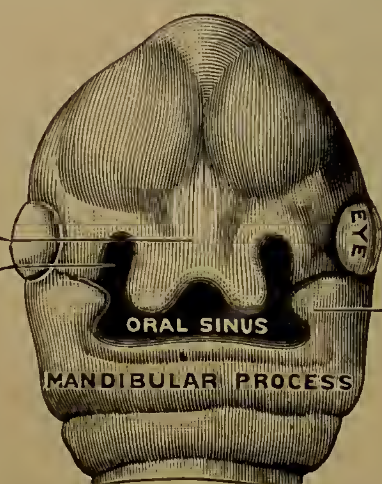


FIG. 99.—Development of the face. (His.)

The Teeth and Salivary Glands.

As early as the sixth week of development there appears, dipping into the lower and upper surfaces respectively of the maxillary and mandibular processes, a thickening of the ectoderm, whose cells subsequently arrange themselves into an anterior and posterior layer, the space which appears between these layers becoming the groove between the lip and the gum (Fig. 100). From the posterior layer a horizontal ridge grows inward into the substance of each gum, forming the *dental shelf*, and upon the under or upper surface of each shelf ten thickenings arise, each of which forms a more or less globular mass of cells, the *enamel organ*, connected with the dental shelf only by a narrow neck which ultimately disappears. In the mesoderm beneath each organ a rapid proliferation of cells forms a papilla, over which the enamel organ is folded like a cup, those cells of the papilla which are in contact with the enamel organ becoming, like the outermost cells of the latter, cylindrical, and forming the *odontoblasts*, whose office it is to deposit the dentine between themselves and the enamel organ. This they begin to do at about the end of the fourth month of development, and at about the same

time the *enamel* begins to be formed by the lower ends of the deeper layer of cells of the enamel organ becoming transformed into calcareous prisms. Finally, around the outside of that portion of the papilla which is not covered by the enamel organ

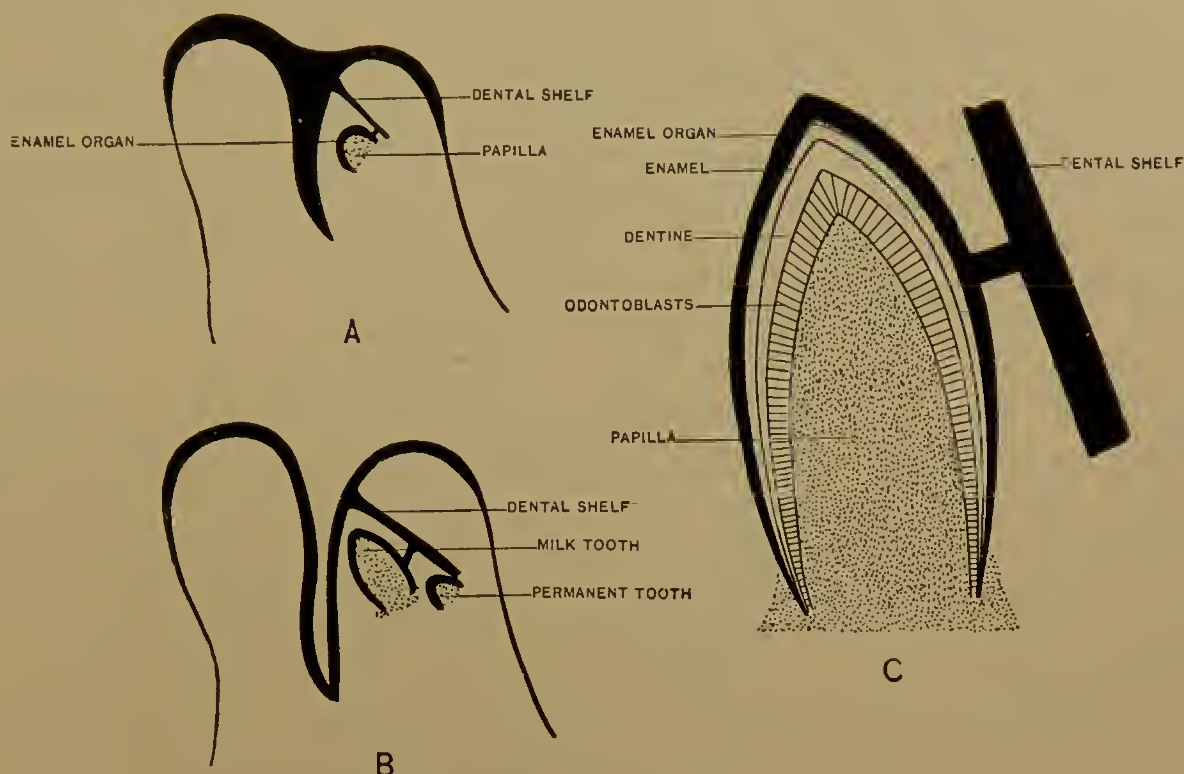


FIG. 100.—Diagram of the development of a tooth.

there appears, about the fifth month, a deposition of bony matter derived from mesodermal cells and constituting the *cement*.

After the separation of the anlagen of the milk teeth from the dental shelf the latter continues to sink deeper into the substance of the jaw, and opposite each milk tooth a *second enamel organ* arises from it, and, mesodermal papillæ also forming as before, the anlagen of the permanent incisors, canines, and premolars are formed. The permanent molars arise in a similar manner from a lateral extension of the dental shelf, and as soon as all the anlagen are formed the tissue of the shelf in the intervals between the various teeth begins to disappear, occasionally, however, persisting in irregular masses until adult life, and producing various abnormalities.

In addition to the teeth certain glandular structures develop from the epithelium of the oral cavity, the most important of which are the *salivary glands*, which arise as simple tubular evaginations, and gradually, by branching, become more and more complicated.

The Branchial Clefts and the Structures derived from Them.

At each side of the pharynx there are, as already stated, four furrows (Fig. 99), represented internally by corresponding depressions, so that along each furrow the pharyngeal epithelium is in contact with the ectoderm of the surface of the body. In the lower vertebrates actual perforation of the thin membrane so formed occurs, forming the gill-slits, but in birds and mammals the perforations do not develop. The first furrow lies immediately behind the mandibular process, and between the members of each successive pair of furrows is a thickened ridge, constituting a branchial arch, each arch being homologous with the maxillo-mandibular processes, which really represent the first arches, the mouth being the first branchial cleft. As development progresses the second arch of each side grows more rapidly than the others, which are in consequence pushed inward toward the median line, and a deep depression is formed at the side of the neck, the *sinus præcervicalis*. From the posterior edge of the second arch a fold grows backward over the mouth of this sinus, and eventually completely covers it in by uniting posteriorly with the side of the body.

From or in connection with the branchial arches or clefts a number of structures develop, some of which may be considered here. From the epithelium of the fourth pair of clefts two thickenings develop, and subsequently fuse together, the single mass so formed growing backward toward the pericardium, separating from the clefts, and enlarging by branching at its posterior end. It forms the *thymus gland,* whose epithelial anlage becomes early infiltrated with lymphatic tissue, and which, subsequent to the second year after birth, begins to undergo degenerative changes. The *thyroid gland* arises partly from the last pair of clefts as paired hollow evaginations, and partly from a median evagination of the floor of the pharynx in the vicinity of the second branchial arch. These anlagen early fuse together, and the gland usually loses all connection with the pharynx, the foramen cæcum at the base of the tongue representing, however, the place of the origin of the median anlage.

The tongue is, embryologically, partly a product of the pharyngeal region, and arises from two anlagen. Its anterior portion arises as a thickening of the floor of the oral cavity, its back portion, however, developing as a pair of thickenings situated in the vicinity of the second and third branchial arches. These thickenings extend forward and outward, forming a V-shaped mass, which encloses in front the posterior end of the anterior anlage. The junction of the two anlagen is indicated in the adult by the V-shaped groove in which the circumvallate papillæ are situated, the foramen cæcum, already referred to in connection with the thyroid gland, lying at the apex of the groove.

The Trachea and Lungs.

Below, the pharynx communicates with the tubular œsophagus, and on the inner surface of the upper part of this there early appears a longitudinal groove, from the lower end of which two pouch-like outgrowths develop. As soon as these begin to form the groove begins to be constricted from below upward from the œsophagus, and becomes the trachea and larynx, the constriction not continuing to complete separation, so that the larynx communicates above with the pharynx. In the connective tissue of the walls of the trachea cartilaginous rings develop, the uppermost of which form the cricoid and arytenoid cartilages of the larynx, the thyroid cartilage being produced by the fusion of the ventral ends of two pairs of cartilaginous bars which are primarily developed in the mesoderm of the fourth and fifth branchial arches. The pouch-like outgrowths are the anlagen of the lungs, and at an early stage become lobed, three lobes appearing in the right lung and two in the left. Secondary and tertiary sacculations later appear, and the complicated structure of the adult lung is acquired. It is to be noted that the epithelium of the lungs, trachea, and larynx is of endodermal origin.

The Intestine and Mesenteries.

From that portion of the primitive intestine which succeeds the œsophagus, the stomach and intestines, together with the liver and pancreas, develop. Of the two structures which in early embryonic life are connected with it, the allantois early separates, its intra-embryonic portion persisting as the urinary bladder and the urachus, while the stalk of the umbilical vesicle retains its connection until after birth, the intra-embryonic portion of it occasionally persisting even into adult life as a more or less pronounced diverticulum of the lower part of the small intestine, known as Meckel's diverticulum.

At first the intestine is a simple straight tube attached to the dorsal wall of the abdominal cavity by a dorsal mesentery, formed by the reflection over it of the peritoneal lining of the abdominal cœlom. Its upper portion is also attached to the anterior wall of the abdomen by a ventral mesentery, whose lower border is falciform in shape, and is attached to the abdominal wall at the umbilicus. This simple arrangement, however, soon disappears, as the intestine,

growing in length more rapidly than the cavity in which it lies, is pushed out into a loop, as is represented in Fig. 101. The elongation continuing, the loop

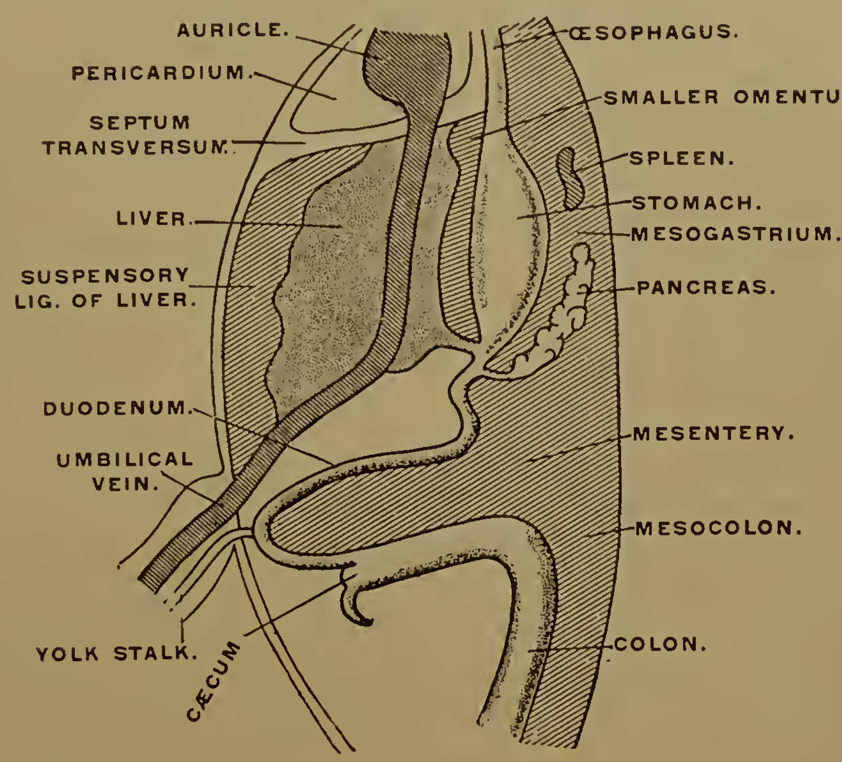


FIG. 101.—Diagram of the human mesentery in its primitive relations. (C. S. Minot.)

bends upon itself, that portion of the intestine which will become the *transverse colon* passing over the portion which is to become the *duodenum.* During the elongation of the intestine the edge of the dorsal mesentery which is attached to it undergoes a corresponding increase in length, while at the line of attachment to the body-wall it increases but slightly, the mesentery of the loop in consequence assuming a fan-like form, and, when the twisting of the loop supervenes, becoming funnel-like.

By this time a differentiation of the intestinal tube has occurred, the portion of it above the loop becoming enlarged to form the *stomach*, while the portion of the loop which passes transversely across the abdominal cavity and the portion of the intestine below this becomes the *large intestine.* The *cæcum* develops as an outgrowth from the large intestine at the point where it is joined by the small intestine, and the *vermiform appendix* is an outgrowth from the cæcum. The

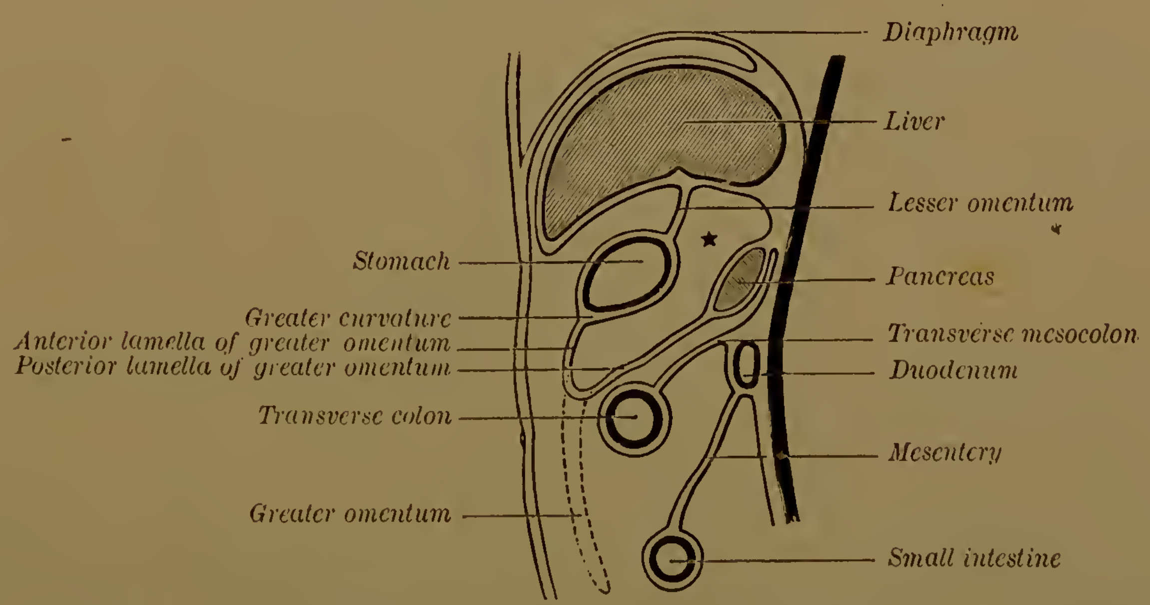


FIG. 102.—Diagram to illustrate the history of the human mesentery—earlier stage. (Hertwig.)

further changes in the intestine consist principally of a continued elongation, especially of the *small intestine*, and of the occurrence of fusion and degeneration of certain portions of the mesentery. Thus, the *mesentery* attached to the transverse colon, primarily radiating from the apex of the mesenterial funnel, later

extends its insertion laterally upon the body-wall, forming a transverse sheet, the mesocolon. This passing over the duodenum binds it fast to the posterior wall of the abdomen, and as a result the duodenal mesentery degenerates. The ascending and descending colon likewise come to lie in contact with the abdominal wall, and their mesentery degenerates to a certain extent, their lower portions being only covered, and not enclosed, by peritoneum.

The *stomach*, in the mean time, has also been undergoing certain changes in position. At first it is straight, what later becomes the small curvature being directed anteriorly; but soon its pyloric end shifts over toward the right side of the body, and, at the same time, the entire structure twists in such a manner that its original left surface becomes anterior, and the small curvature is directed to the right.[1] As the result of this the portion of the dorsal mesentery which is attached to the stomach becomes thrown into a pouch lying behind the stomach, the cavity of the pouch forming the omental cavity, and its floor later being drawn downward to form the great omentum, the posterior layer of which, as it passes back to the body-wall, fuses with the mesocolon.

During the progress of these changes a pair of outgrowths have been developing from the duodenum and passing forward between the two layers of the ventral mesentery. They unite to form the *liver*, which quickly reaches a large size—so large, in fact, that the two layers of the mesentery cannot quite meet around it,

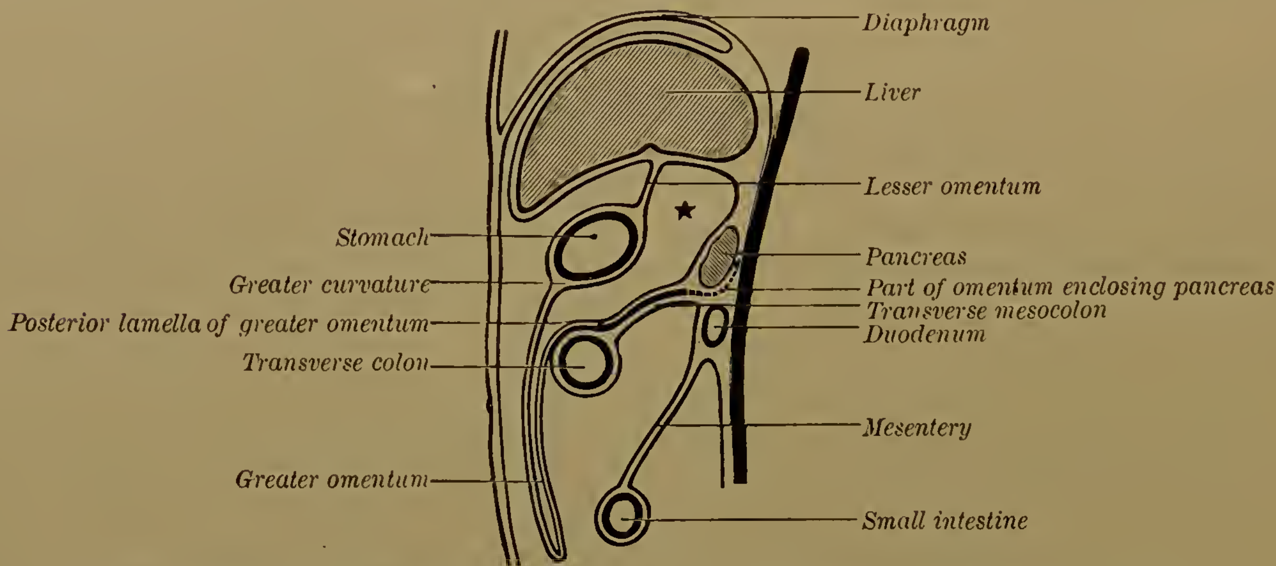


FIG. 103.—Diagram to illustrate the history of the human mesentery—later stage. (Hertwig.)

but are reflected from its sides as the coronary ligaments. The upper portion of the mesentery, above the liver, remains unchanged, however, forming the falciform ligament, while the portion below is affected by the torsion of the stomach, so that its faces come to lie dorsally and ventrally, instead of right and left, and it forms the small omentum (Figs. 102, 103).

The Liver and Pancreas.

The *liver* arises as a pair of hollow outgrowths from the ventral surface of the upper part of the duodenum. Each outgrowth, which represents one of the lobes of the adult liver, becomes greatly complicated by the development of numerous lateral solid branches, these developing others, and so on, the various branches uniting with one another to form a network in the meshes of which are found capillary blood-vessels. The solid branches, termed *hepatic cylinders*, become converted partly into *bile-ducts* and *capillaries* by hollowing out, and partly into the liver *parenchyma*, the original network becoming more or less inconspicuous. The various bile-capillaries unite to form the right and left hepatic ducts, which

[1] It may be pointed out that this twisting is the cause of the position of the pneumogastric nerves in their course over the stomach in the adult, the left nerve passing in front of and the right nerve behind the viscus.

at first open separately into the duodenum; but later the duodenum becomes pouched where they enter, and this pouch is drawn out to form the *common bile-duct*, from which the *gall-bladder* and *cystic duct* arise as a hollow evagination.

The *pancreas* arises as a hollow evagination of the dorsal wall of the duodenum opposite the point where the liver anlagen appear, and grows dorsally between the two layers of the dorsal mesentery, gradually becoming very much branched. It is affected by the torsion of the stomach, so that it assumes a transverse position in the abdominal cavity, and on the development of the mesocolon is pushed with the duodenum against the dorsal wall of the abdomen, its mesentery in consequence undergoing degeneration. Its duct, which at first is attached to the dorsal surface of the duodenum, gradually moves around toward the ventral surface, and finally, as a rule, unites with the common bile-duct.

ORGANS DERIVED FROM THE MESODERM.

The primitive layers of the mesoderm have their cells arranged at first in an epithelial manner, and this arrangement is preserved by certain portions of the layers for a considerable time, even, it may be, throughout life; to these portions the term *mesothelium* may be applied. At certain regions, however, cells are budded off from the primitive layers to form irregular masses, or become scattered throughout the body without any definite arrangement; and these cells are termed *mesenchyme*. It is possible, in accordance with this division of the mesoderm, to recognize mesothelial and mesenchymatous organs.

The Skeleton.

From the mesenchyme are derived the connective and supportive tissues of the body, whose histological differentiation need not be considered here. A few statements may be made, however, concerning the development of the skeleton. The first trace of a supportive structure in the embryo is the *notochord* (Fig. 104),

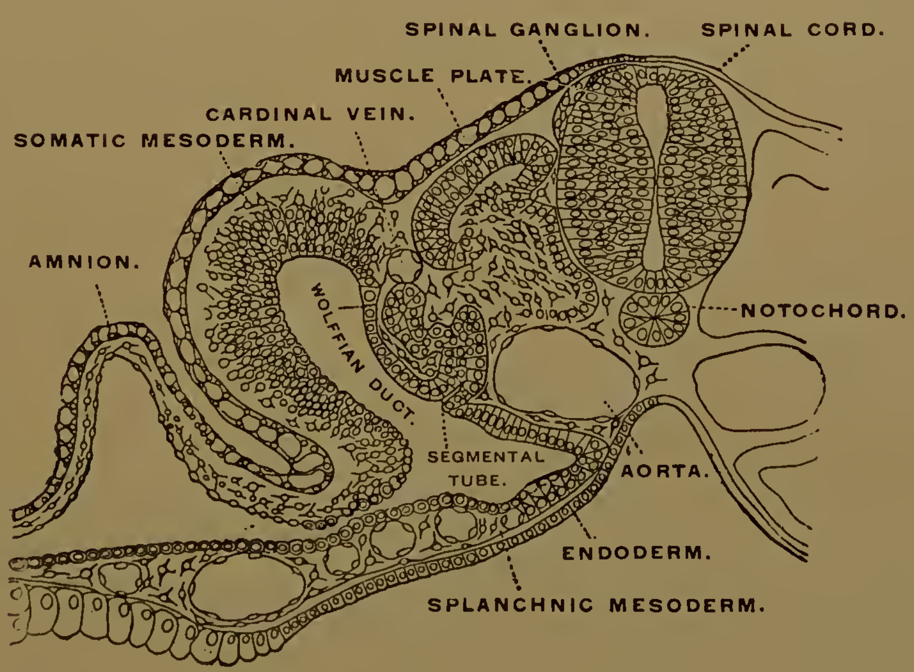


FIG. 104.—Cross-section of embryo.

whose formation has already been described, and which is practically a transitory structure, being replaced later by the spinal column and skull. From a portion of each of the mesodermal somites a mass of cells is budded off, and these masses arrange themselves on either side of the notochord, which they eventually enclose, growing dorsally at the same time around the spinal cord. Each mesenchymatous mass so produced by the members of each pair of mesodermal somites early becomes converted into a mass of hyaline cartilage, which later ossifies to form the *vertebral centrum*; and, as the ossification proceeds, portions of the notochord enclosed by the

centra are gradually encroached upon and finally disappear, the intervening portions persisting as the gelatinous substance of the intervertebral disks. The *neural arches* develop a little later than the centra, and ossify separately, uniting with the centra only after birth.

The *ribs* arise by the chondrification and subsequent ossification of the mesenchymatous tissue situated between the members of each pair of mesodermal somites, the ribs of the thoracic region being, however, the only ones which undergo complete development, extending in the wall of the body to the ventral surface, where a number of them unite to form the sternum. In the other portions of the trunk and in the neck they remain small, and become united with the vertebræ, being represented in the cervical region by the ventral portions of the transverse processes, in the lumbar region by the costal processes, and in the sacrum by the lateral masses.

The *skull* shows from the beginning no trace of being composed of distinct vertebræ, except in the occipital region. The first trace of the skull is found in two cartilaginous bars, placed one on each side of the anterior end of the notochord. These are the *parachordal cartilages* (Fig. 105), and in front of them two other cartilages known as the *trabeculæ cranii* are formed. These four cartilages eventually unite together, and the trabeculæ uniting at their anterior extremities to form a plate, known as the *ethmo-vomerine plate*, a cartilaginous basis cranii is formed, which later extends dorsally behind and at the sides, leaving, however, the greater portion of the brain covered only by membrane. About the third month of development centres of ossification begin to appear in this chondro-cranium, resulting in the formation of a number of separate bones, which later fuse with one another to a certain extent to form the occipital, sphenoid, and ethmoid bones, all of which are really composite bones.

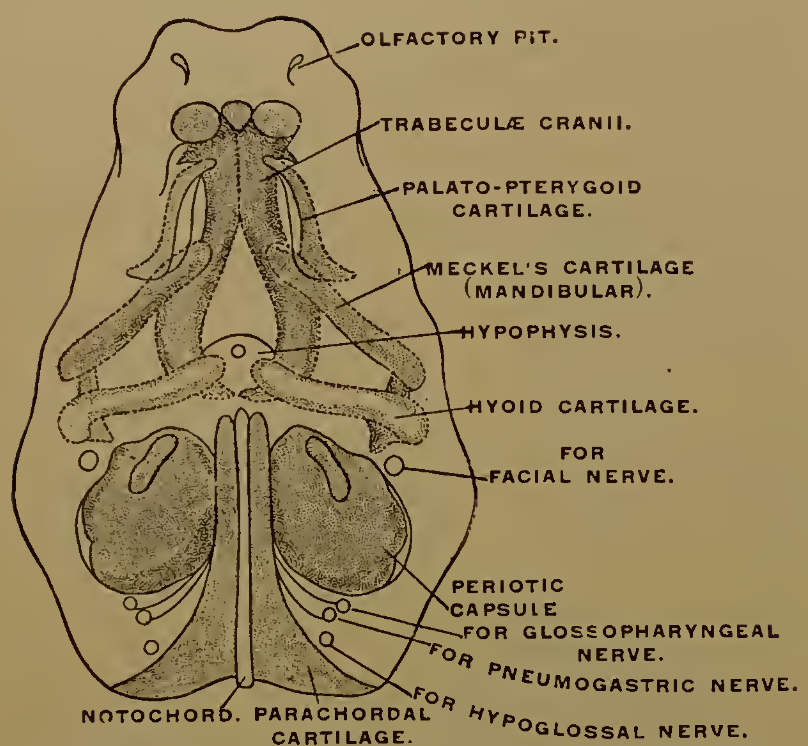


FIG. 105.—Cranial cartilages of embryo. (C. S. Minot, after W. K. Parker.)

In addition to the bones which are thus developed, other elements occur in the skull and may be arranged in three groups: (I.) A number of bones are developed without being preformed in cartilage, their osseous matter being deposited directly in fibrous connective tissue. In this way—as *membrane bones*, as they are termed—are formed the parietals and frontals and the bones of the face, such as, for example, the nasals, malars, lachrymals, palatines, and maxillæ. (II.) Around each auditory organ a cartilaginous case, the *periotic capsule*, develops, quite independently of the primary chondro-cranium, filling up a gap in its walls on each side between the occipital and sphenoid bones, and from it are formed the petrous and mastoid portions of the temporal, the squamous and tympanic portions being membrane bones, which secondarily unite with the capsule. (III.) In each branchial arch a cartilaginous bar develops, these bars forming what is termed the *visceral skeleton*, and certain of them become intimately related to the skull. The dorsal end of the maxillo-mandibular cartilage becomes entirely replaced by membrane bones, the maxillæ, palatines, and internal pterygoid plates of the sphenoid; while its lower end, known as *Meckel's cartilage*, ossifies and unites with a number of membrane bones, which enclose it, to form the lower jaw or mandible, and also takes part in the formation

of the ossicles of the middle ear. The cartilages of the second and third arches unite to form the hyoid bone, the small horn, the stylo-hyoid ligaments, and the styloid processes of the temporals representing the complete second arch, while the great horn represents the incomplete third arch. The fourth and fifth arches become greatly reduced, and fuse together, as already indicated, to form the thyroid cartilage of the larynx.

The *bones of the extremities* are all preformed in cartilage, and for the long bones at least two or three centres of ossification are usually present, one being for the shaft and one for each epiphysis, these latter, however, being merely provisions for the growth in length of the bone, and not representing originally distinct bones. In the scapula, however, two primary centres are formed, one for the greater portion of the bone, and one for the coracoid process, which in the lower vertebrates is a distinct bone; and similarly three primary centres are found in each hip-bone, one for the os pubis, one for the ischium, and one for the ilium, each of these being primarily a distinct bone. In the carpus and tarsus certain fusions also occur. Typically, each consists of nine bones arranged in a proximal row of three bones, a distal row of five bones, and a single bone between the two. The following scheme will show the fusions which have taken place, each composite bone ossifying from two centres, the rest from one:

Carpus.		*Tarsus.*	
Scaphoid,	Radiale.	Tibiale,	Astragalus.
Semilunar,	Intermediate.	Intermediate,	
Cuneiform,	Ulnare.	Fibulare,	Calcaneum.
(Fused with Scaphoid)	Centrale.	Centrale,	Navicular.
Trapezium,	Carpal I.	Tarsal I.,	Internal Cuneiform.
Trapezoid,	" II.	" II.,	Middle Cuneiform.
Os Magnum,	" III.	" III.,	External Cuneiform.
Unciform,	" IV.	" IV.,	Cuboid.
	" V.	" V.,	

The pisiform does not belong to the same category as the other carpal bones, being an ossification in the tendon of the flexor carpi ulnaris, just as the patella is an ossification in the tendon of the quadriceps extensor femoris. Such bones are known as sesamoid bones.

The Heart and Blood-vessels.

It has already been seen that the formation of the blood-vascular system begins in the area opaca of the blastodermic vesicle, and thence extends toward the embryo, two vessels, the *vitelline veins,* carrying the blood from the yolk-sac to the embryo. While the embryo is still spread out flat upon the surface of the blastodermic vesicle the splanchnic layer of the mesoderm on each side of the body buds off a small collection of cells (Fig. 106, *endocardium*) into the space between it and the endoderm; these early arrange themselves in a tubular form and become enclosed within a fold of the splanchnic mesoderm. These folds (Fig. 106, *myocardium*) and tubes so formed are the anlagen of the heart, the two halves of which are at first widely separated; but as the embryo becomes constricted off from the yolk-sac they are brought nearer together, and finally unite to form a single double-walled tube, the folds becoming the muscular walls of the heart, while the mesenchymatous tubes form its endocardium.

The *heart,* thus formed, is situated in the neck region of the embryo, and has communicating with it behind the vitelline veins, while anteriorly it is continued into the aortic trunk. This simple tubular heart now undergoes a considerable increase in length, and, as a result, bends upon itself in an S-shaped manner (Fig. 107), the aortic end being ventral to the venous. The venous end now begins to enlarge, and pouches out into a sac on each side, forming the *right* and *left auricles;* and

from its dorsal wall between the two auricles a vertical partition begins to form, which, growing backward toward the horizontal portion of the heart, would separate the auricles completely were it not that a foramen forms in its upper part

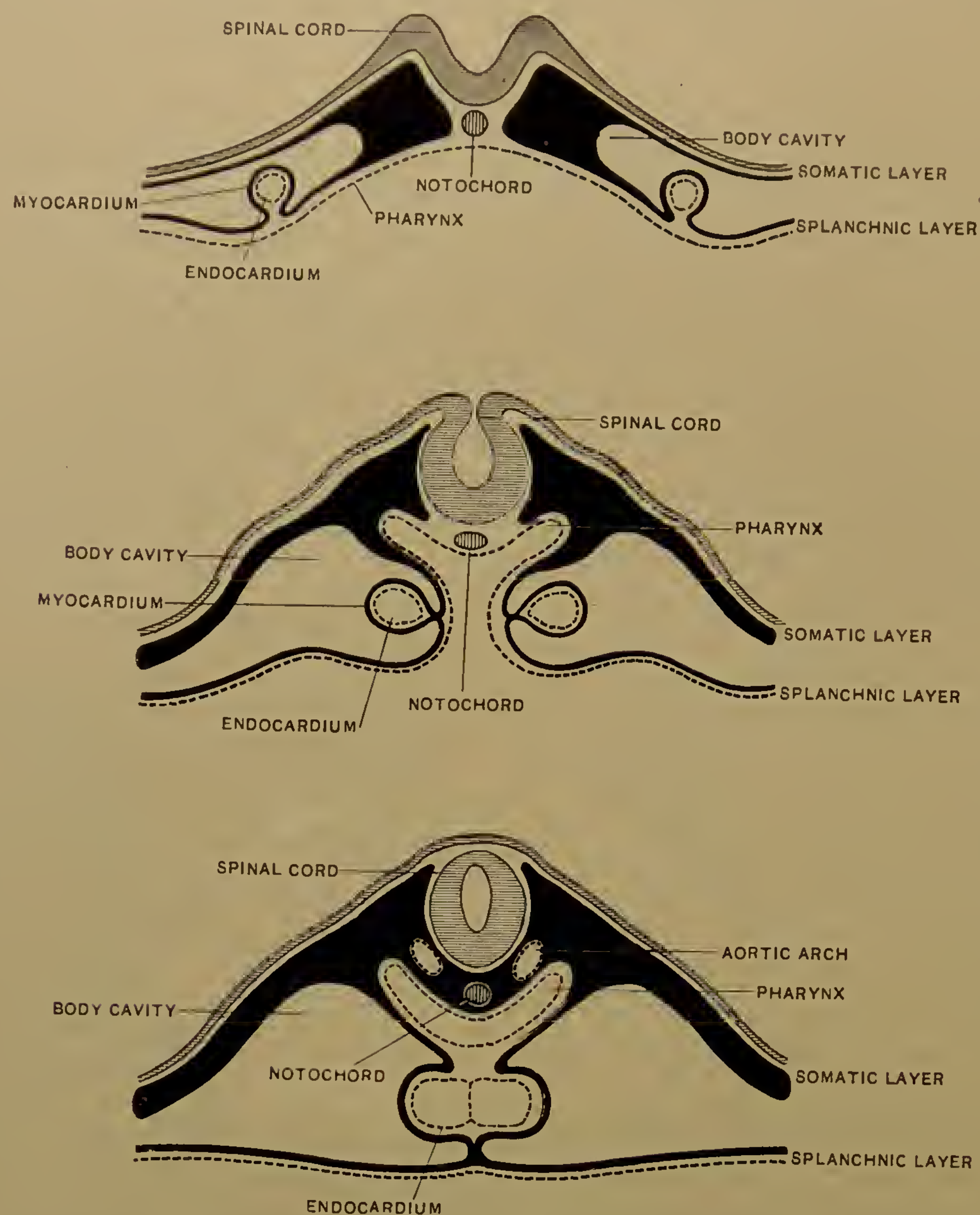


FIG. 106.—Development of the heart: cross-sections of the cervical region of an embryo; diagrammatic. (Testut.)

(the *foramen ovale*), which persists until birth, closing normally shortly thereafter. The partition passes to the left of the opening by which the blood from the vitelline

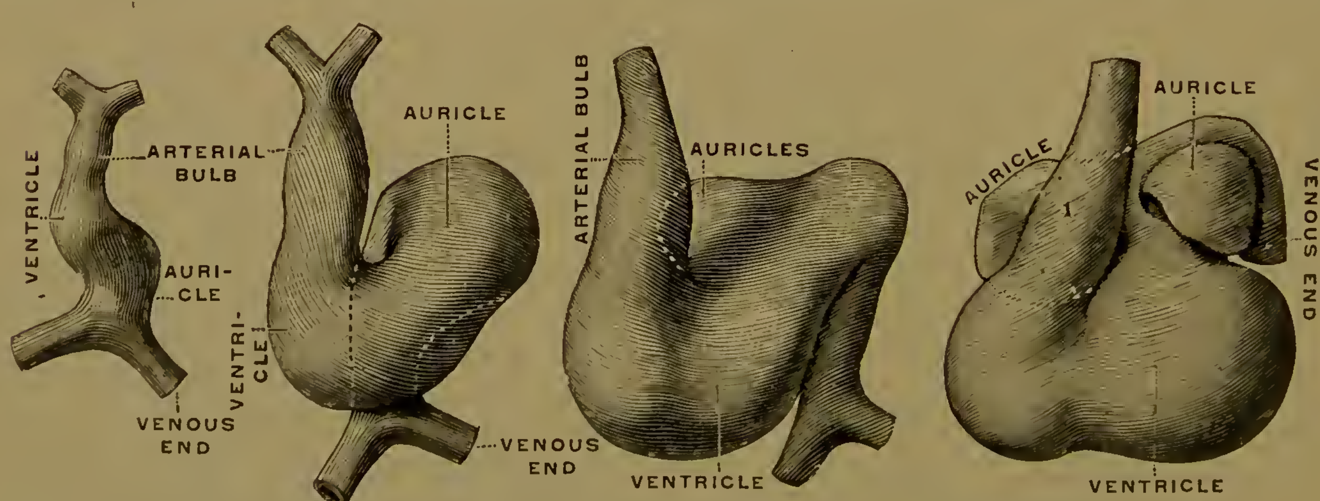


FIG. 107.—Four stages in the development of the heart: front view; diagrammatic. (Testut.)

veins flows into the heart, and, consequently, this opening now communicates with the right auricle, the left receiving four small veins which come to it from the lungs.

The point of union of the auricular and ventricular regions has in the mean time become considerably constricted, and the auricular septum extends far enough

downward to divide the opening between them into two parts. In the ventricle a crescentic partition develops from the posterior and dorsal walls, and grows upward toward the auricular septum, with the lower border of which it unites, ending, however, in a free edge beneath the opening by which the aortic trunk communicates with the ventricle. The *aortic trunk* has meanwhile flattened dorso-ventrally, and on the inner surfaces of the flat sides two ridges develop, and finally unite, dividing the lumen of the aortic trunk longitudinally into two portions (Fig. 108). The partition extends down into the ventricle, and unites

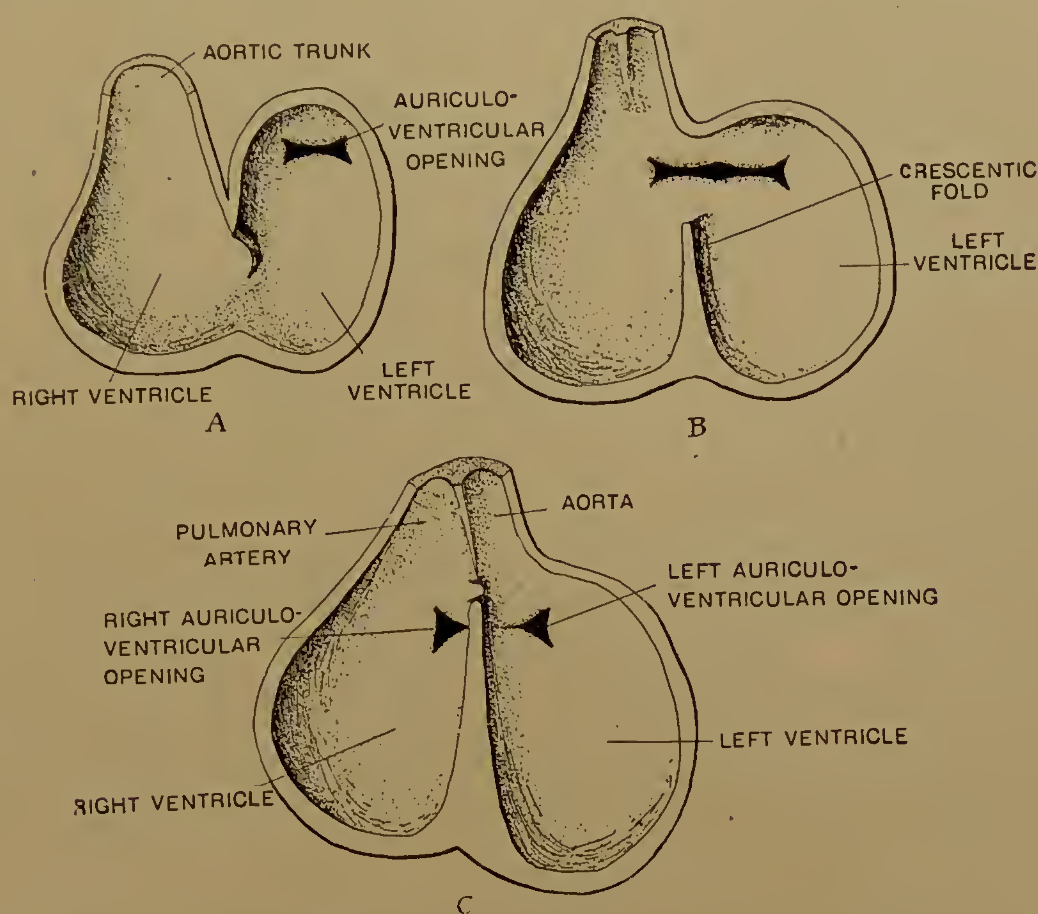


FIG. 108.—Development of the aorta and pulmonary artery. (After Born.)

with the free edge of the ventricular septum, so that the *division of the ventricle* becomes complete, and the aortic trunk then separates completely into two tubes, one of which, the *aorta*, communicates with the left ventricle, while the other, the *pulmonary artery*, opens into the right ventricle. The original tubular heart has thus become converted into a four-chambered organ which differs from the adult heart only in the existence of the foramen ovale in the auricular septum.

The aortic trunk, prior to its division, in passing forward from the heart gives off from time to time pairs of lateral branches, which pass dorsally in the branchial arches. These are the *aortic arches*, which, on each side, unite above the branchial clefts to form a longitudinal vessel, and this, passing backward, unites with its fellow of the opposite side to form the *dorsal aorta* (Figs. 109, 110). This primitive condition is, however, merely transitory, the first arches early disappearing, and then the second, the continuations of the aortic trunk from which these arches arise persisting, however, to form the *external carotid arteries*, while the branches of the dorsal aorta into which they opened likewise persist to form the *internal carotids*. The third arches persist, becoming portions of the internal carotids, and forming the connections between those arteries and the external carotids; but the portions of the branches of the dorsal aorta which intervene between the third and fourth arches disappear, thus cutting off the direct connections of the internal carotids with the dorsal aorta. The fourth arch of the left side persists in its entirety, forming the arch of the aorta of the adult, and is the only connection between the heart and the dorsal aorta, since the right branch of the dorsal aorta disappears completely behind the third arch, the right fourth arch forming part of the right *subclavian artery*. The fifth arches give rise to an artery on each side, the pulmonary arteries, and the portion of the arch distal to the branch on the right

side disappears, but persists on the left side to form the *ductus arteriosus*, uniting the pulmonary artery with the dorsal aorta—a connection functional for the passage of blood up to birth, but aborting later.

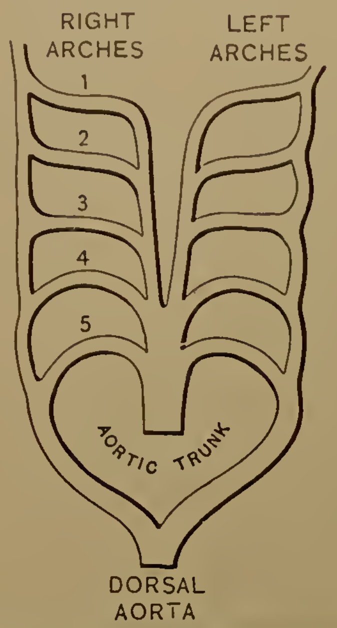


FIG. 109.—Aortic arches, early arrangement. (After Rathke.)

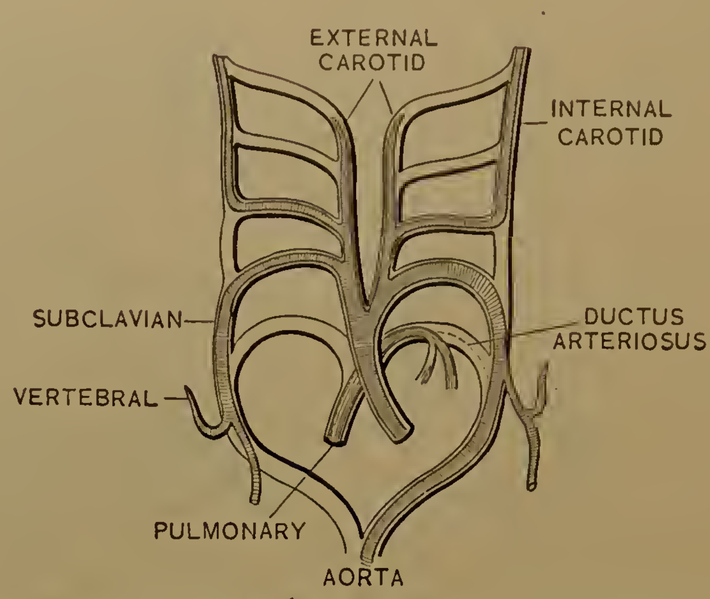


FIG. 110.—Aortic arches, final condition. (After Rathke.)

Of the *venous system* it has already been seen that there is a pair of vitelline veins coming from the yolk-sac and opening into the venous end of the embryonic heart. In addition to these, other veins are developed at an early period, which unite together and with the vitelline veins before entering the heart, forming a *sinus venosus*, which later is taken up into the right auricle. Of these veins there are, first, the umbilical veins, which bring back the blood from the placenta, entering the body of the embryo at the umbilicus (Fig. 111). The left umbilical vein

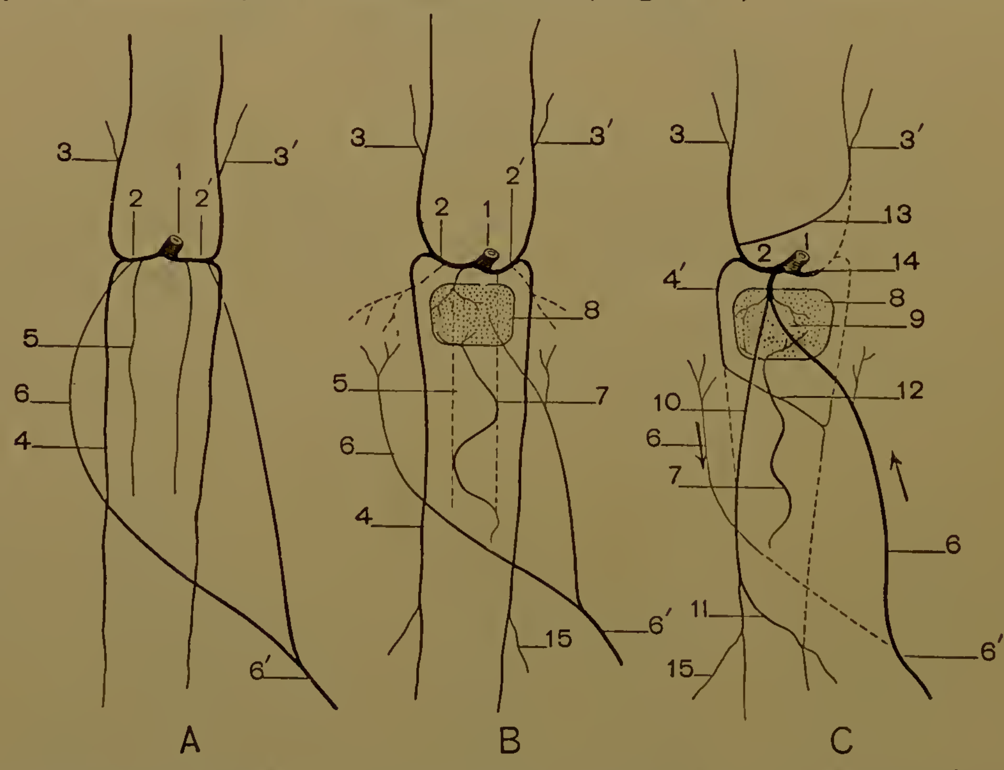


FIG. 111.—Development of the veins: *A*, primitive condition, bilateral symmetry; *B*, formation of portal system; *C*, final condition; diagrammatic. 1, sinus venosus; 2, right ductus Cuvieri; 2′, left ductus Cuvieri; 3, right jugular vein; 3′, left jugular vein; 4, cardinal vein; 4′, vena azygos major; 5, vitelline vein; 6, umbilical vein; 6′, umbilical vein in cord; 7, portal vein; 8, liver; 9, ductus venosus; 10, vena cava inferior; 11, common iliac vein; 12, vena hemiazygos; 13, left brachio-cephalic vein; 14, coronary sinus; 15, veins of lower limbs. Atrophied parts in broken lines. (Testut.)

degenerates later almost entirely, but the right passes forward in the ventral midline of the abdomen to the under surface of the liver, to which it distributes blood, continuing onward, however, to open into the sinus venosus. During embryonic life this vein increases in size, the vitelline veins, on the other hand, becoming smaller and, forming connections with one another, eventually giving rise to the portal vein. After birth, however, as soon as the placental circulation ceases, the

umbilical vein becomes converted into a solid cord of tissue, which, from the transverse fissure of the liver to the umbilicus, is known as the *round ligament*, while the portion above this becomes the *ductus venosus*, the uppermost part persisting as the upper part of the *vena cava inferior* and receiving the hepatic veins.

Secondly, there are two other pairs of veins which are entirely confined to the embryo—the *jugulars*, which bring back to the heart the blood from the head and upper extremity, and the *cardinals*, which return the blood from the trunk and lower limb, the jugulars and cardinals of each side of the body uniting together before opening into the sinus venosus to form a transverse branch, the *ductus Cuvieri*. As the embryo develops the jugulars increase in size more rapidly than the cardinals, so that the Cuvierian ducts seem to be the continuations of the jugulars; and when the sinus venosus is taken up into the right auricle the two Cuvierian ducts and the umbilical vein, which open into the sinus from the right and left sides and from below, respectively, come to have separate openings into the auricle, forming the three principal openings found in the adult.

The cardinal veins do not, however, persist until adult life in their original condition, but are to a certain extent replaced by an unpaired venous trunk, the *vena cava inferior*, which makes its appearance in the tissue between the two primitive kidneys, and early unites with the cardinals by means of transverse branches, through which it receives the blood from the kidneys and rapidly increases in size. In the mean time, a connecting trunk has formed between the left and right cardinals, and the main mass of the blood from the left lower limb flows over into the right cardinal, which thus becomes enlarged and forms apparently the continuation of the inferior vena cava. Above, the vena cava opens into the umbilical vein, and, on the degeneration of the umbilical after birth, this uppermost part of it persists as the upper end of the vena cava. This vessel is, therefore, composed of three originally distinct parts: (1) the independent trunk between the primitive kidneys; (2) the lower end of the right cardinal vein; and (3) the uppermost part of the umbilical. When completely formed it receives the blood from the greater part of the territory originally drained by the cardinals, the upper portions of these latter still continuing, however, to receive the blood from the intercostal spaces of the thorax. The lower part of the left cardinal completely disappears, and it also loses its connection with the left ductus Cuvieri, forming instead a transverse connection with the right cardinal, and becoming the *vena hemiazygos* (azygos minor) of adult anatomy, the upper part of the right cardinal becoming the *vena azygos major*.

In the mean time, a slight change has taken place in the jugulars, a branch passing across from the left to the right, and forming the *left brachio-cephalic vein* of the adult, which receives and passes over to the right jugular all the blood returning by the left jugular. As the result of this the portion of the left jugular between the origin of the left brachio-cephalic vein and the left ductus Cuvieri becomes greatly reduced, being represented in the adult only by the small oblique vein on the back of the left auricle; but the left ductus Cuvieri, thus separated from both the jugular and the cardinal vein which originally opened into it, does not degenerate, since it still receives a large proportion of the blood returning from the tissue of the heart itself through the coronary veins, but persists as the coronary sinus.

The Diaphragm.

Closely associated with the development of the venous trunks is the formation of the diaphragm. At first the body-cavity or cœlom is a continuous cavity extending the entire length of the trunk, and even into the head region; but during development the portions in the head and neck disappear, the thoracic and abdominal portions persisting, and being at first continuous. After the heart has formed, however, a thick transverse partition, the *septum transversum*, begins to grow from the ventral and lateral walls of the body toward the sinus venosus,

enclosing the venous trunks which open into the sinus. By its formation the thoracic and abdominal portions of the cœlom are almost completely separated, the only communication between them being by a pair of small canal-like openings, one on each side of the dorsal mesentery; and, as the lungs develop, they push the walls of the canals in front of them, these walls thus forming the pleuræ. At a comparatively early stage of development the pericardial portion of the thoracic cavity becomes separated from the pleural portions; and considerably later the latter become cut off from the abdominal cavity, then known as the peritoneal cavity, by the growth forward from the dorsal wall of the body of a partition which unites with the free edge of the septum transversum.

The Lymphatic Vessels, the Spleen, and the Suprarenal Capsules.

Of the development of the *lymphatic vessels* comparatively little is known with certainty, though they seem to be formed similarly to the blood-vessels by a hollowing out of strands of mesenchymatous cells. The mode of development of the *spleen* is also but imperfectly known: it arises as a collection of mesenchymatous cells situated between the layers of the dorsal mesentery of the stomach, and early receives a rich supply of blood-vessels.

The *suprarenal bodies* are formed from certain tubules of the mesonephros (see below), a rich nerve-supply from the abdominal portion of the sympathetic system later penetrating into the tissue. *Accessory suprarenals*, also known as *Marchand's adrenals*, occur in the broad ligament of the female and the spermatic cord of the male, and are also formed from some tubules of the mesonephros.

The Muscular System.

From the mesothelial portions of the mesoderm the voluntary muscles and the urino-genital system develop. The voluntary muscles are derived from the mesodermal somites, the greater portions of which become transformed into muscle-tissue, and, consequently, the voluntary musculature has primarily a segmental arrangement, consisting of a series of muscle-plates placed one behind the other on each side of the body, and extending forward even into the head-region of the embryo. Each plate is supplied by a cranial or a spinal nerve, and has the fibres of which it is composed directed longitudinally, and arising from and inserted into the connective-tissue membranes which separate each pair of plates. This primitive arrangement, however, is not long retained, the various muscle-plates fusing together to a greater or less extent, and dividing longitudinally and into various layers, and so producing the complicated muscular system of the adult.

The involuntary muscle-tissue which occurs distributed through the walls of the various viscera seems to arise by the differentiation of mesenchymatous cells, and to have nothing to do with the mesodermal somites.

The Excretory and Reproductive Organs.

The excretory and reproductive systems arise from certain of the mesodermal somites just where they join the splanchnic and somatic layers, and the first portion of the excretory system to appear arises from certain somites in the vicinity of the heart, a solid cord of cells growing out from each somite toward the ectoderm. Each cord later becomes converted into a canal, which opens at one end into the cœlom, and is connected at the other end with the ectoderm. This collection of tubules is termed the *pronephros* (Fig. 112), and as it develops there is formed from the ectoderm, along the line where the tubules are in contact with it, a longitudinal canal, which later separates from the ectoderm and comes to lie close to the mesoderm (Fig. 104). This is the *pronephric* or *Wolffian duct*, with which the tubules of the pronephros unite, and which opens posteriorly into the urogenital sinus, to be described later.

The pronephros, however, is but a transitory organ, and it soon degenerates; a second excretory organ, the *mesonephros* or *Wolffian body*, makes its appearance, its development being similar to that of the pronephros. Its tubules, which open at one end into the cœlom and at the other into the Wolffian duct, reach a consider-

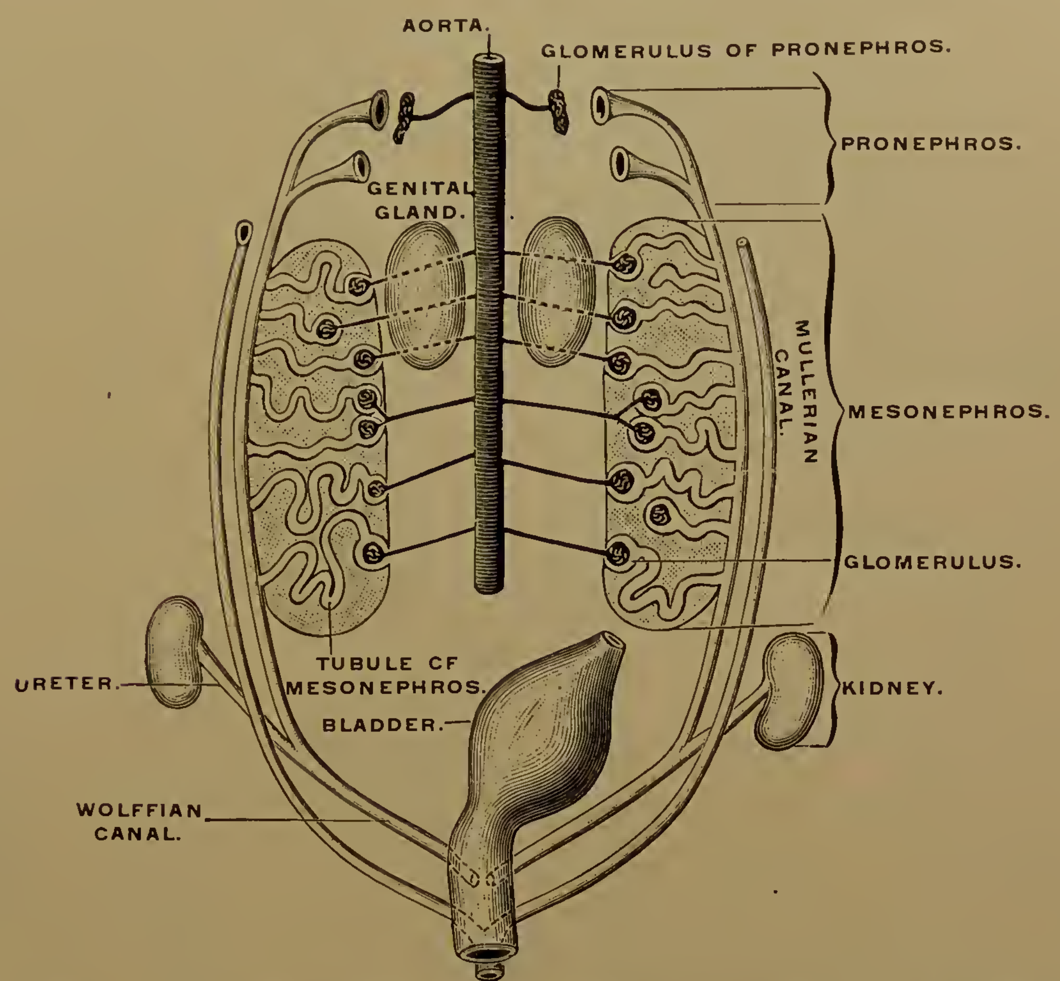


FIG. 112.—Diagram of the various excretory organs successively developed in the formation of the urinary system. (Testut.)

able length, and become much contorted, and a knot of capillary blood-vessels, developing in contact with each tubule, pushes its wall in front of it to form a *glomerulus* projecting into the tubule. The tubules early lose their connection with the cœlom, and, though at first they present a strictly segmental arrangement, this is not adhered to, as secondary and tertiary tubules arise from each mesodermal somite, develop glomeruli, and unite with the primary tubules to open into the Wolffian duct. The Wolffian body thus becomes an exceedingly complicated organ, which, on account of its size, forms a strong projection into the cœlom from the dorsal wall of the body.

But even this second kidney does not persist into adult life as a functional excretory organ, but portions of it degenerate, while other parts are adapted to new functions, its excretory functions being assumed by a new kidney, the *metanephros*. This appears as a tubular outgrowth from the dorsal surface of the lower part of each Wolffian duct, and from the anterior end of this a number of tubules grow out and push their way into a mass of mesodermal tissue which has concentrated around them. The original outgrowths become the *ureters*, and the tubules, which become very numerous, develop into the *urinary tubules*, in connection with which *glomeruli* (Malpighian corpuscles), derived from the mesodermal mass, develop. The compact organ thus formed becomes the functional kidney of the adult.

When the Wolffian bodies are fully developed a cord of cells appears on the lateral surface of each of them, and becomes converted into a canal opening behind into the cloaca and in front into the cœlom. This is the *Müllerian duct*, and by the time it is established a thickening of the peritoneal cells covering the mesial surfaces of each Wolffian body appears, forming the *germinal ridges*, from which the ovaries or testes develop. In the case of the *ovaries* the mesenchyma-

tous tissue immediately beneath the thickenings develop into the stroma, into which cords of cells (Fig. 113) grow from the thickening. Certain of the cells

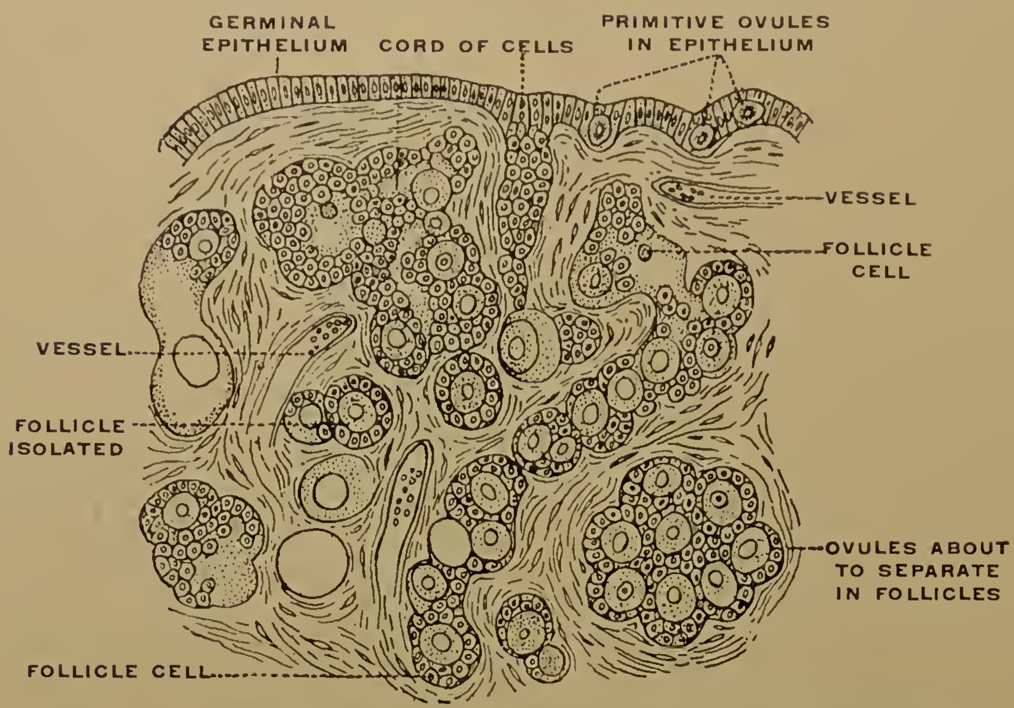


FIG. 113.—Section of the ovary of a new-born child. (After Waldeyer.)

of the cords enlarge greatly and become ova, the remaining cells multiplying rapidly by division and becoming the follicle-cells. Division of the cells which are to form ova appears to cease at about the second year after birth, by which time, therefore, all the ova are differentiated. The *testes* are at first very similar to the ovaries, and have a similar development, the spermatic cells being derived from the cells of the germinal ridge, and the stroma of the ovary being represented by the tunica albuginea and the trabeculæ of the testis.

When mature the ova are extruded from the ovary practically into the peritoneal cavity, though, as a matter of fact, they are usually received at once into funnel-like openings by which the Müllerian ducts communicate with the peritoneal cavity, these ducts becoming the *Fallopian tubes* of the adult, and their lower portions fusing to form the *uterus* and *vagina*. In the embryo, however, the Müllerian ducts extend much farther forward than the position of the ovary, the ostium of the Fallopian tubes being a new formation and not the original terminal opening, the more anterior portion of each duct being probably represented in the adult by the *hydatid of Morgagni* (Fig. 114), a small vesicular structure attached to one of the fimbriæ of the secondary opening. While the ovary and the metanephros have been developing the mesonephros has been degenerating, and all those portions of the Wolffian ducts which lie anterior to the points of outgrowth of the metanephric ducts disappear, except small portions at each end. The upper end, through mesonephric tubules which communicate with it, comes into intimate relation with the ovary, forming with its tubules the *parovarium*, which in the adult lies close to the ovary in the substance of the broad ligament. The lower ends of the Wolffian ducts persist as the *canals of Gärtner*, situated on each side of the upper end of the vagina, while the mesonephros almost completely disappears, its uppermost tubules just mentioned and a small portion of its lower end alone persisting, the latter forming a cyst-like structure lying between the layers of the broad ligament, and termed the *paroöphoron*.

It has been seen that the ovaries appear at the level of the mesonephros—that is to say, well forward in the abdominal wall. This position, however, is not retained, but they descend as development proceeds, and finally lie in the pelvic cavity. This descent is partly produced by the contraction of a band of connective tissue which descends from the lower end of the mesonephros to be attached to the skin in the region where the labia majora will later appear, and which is represented by the *round ligament* of the adult.

The testes and the parts in their neighborhood undergo changes comparable to those just described for the ovaries, the principal difference being that the Müllerian ducts degenerate except at their two extremities, the anterior ends persisting as a small vesicle attached to each epididymis, and known as the *hydatid of the epididymis,* while the lower ends unite together to form a small sac, which opens into the prostatic portion of the urethra, and is termed the *sinus pocularis.* This latter structure from its mode of formation is evidently homologous with the uterus of the female, and has consequently been termed the *uterus masculinus.* On the other hand, the Wolffian ducts persist, forming the *vasa deferentia,* and, as in the female, the tubules of the upper portions of each Wolffian body grow inward toward the testes, with which they unite, their testicular ends forming the *tubuli recti* and *rete testis,* while the ends connected with the Wolffian ducts form the *epididymis.* The remainder of the Wolffian bodies undergoes almost complete degeneration, portions, however, as in the female, persisting, and forming the structures known as the *vasa aberrantia* of the epididymis and the *paradidymis* or *organ of Giraldès.*

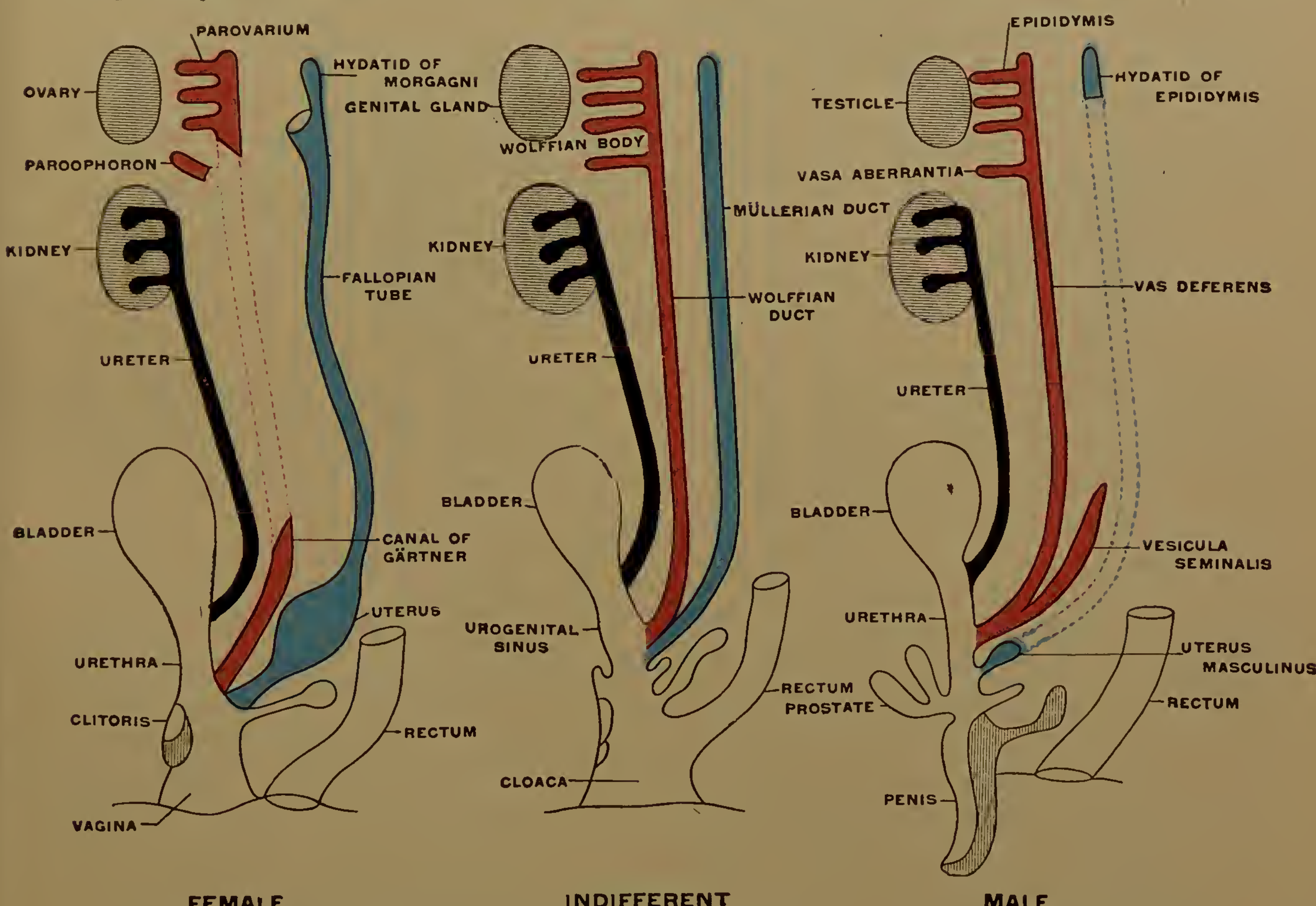


FIG. 114.—Diagram of the development of the genito-urinary apparatus. (Modified from Huxley.)

The round ligament, whose contraction occasions the descent of the ovary into the pelvic cavity, since it is primarily in connection with the mesonephros, has naturally a representative in the male, passing from the lower end of the mesonephros to that region of the skin where the scrotum will develop. By its contraction the descent of the testis is brought about, this organ being drawn first into the cavity of the false pelvis, and then into the inguinal region. Here, in the mean time, on each side, a downgrowth of a finger-like process of peritoneum into the scrotum by the side of the round ligament has occurred, the downgrowth being preceded by prolongations of various muscular layers of the abdominal wall. The testes, continuing their descent, follow these peritoneal downgrowths, and thus come to lie within the scrotum, the peritoneal processes wrapping themselves around them and forming the *tunicæ vaginales,* the neck by which the process communicates with the general peritoneal cavity subsequently closing by the fusion of its walls, while the remaining coverings of the testes are produced by the

muscle- and fascia-layers of the abdominal walls which preceded the peritoneal process. The cord, which represents the round ligament, is to be found in the adult in a small cord which passes from the epididymis to the wall of the scrotum, and is termed the *gubernaculum*.

It has already been stated that the allantois does not entirely degenerate at birth, the middle part of its intra-embryonic portion persisting as the *urinary bladder*, and the part between this and the umbilicus becoming converted into a solid cord, known as the *urachus*. The part between the bladder and the intestine forms what is termed the *urogenital sinus*, and into it the Müllerian and Wolffian ducts open. In the development of the *ureters* the portions of the Wolffian ducts between their point of origin and the sinus are, in the male, gradually taken up into the sinus, so that the ureters and the vasa deferentia have separate openings, the former uniting with the base of the bladder, while the latter open into the sinus. Since the allantois is connected with the intestine, that portion of the digestive tract receives the urinary and genital products as well as the fæces, and thus receives the name of the *cloaca* (Fig. 115). At an early period this cloaca becomes divided by a partition into a dorsal and a ventral portion; this partition becom-

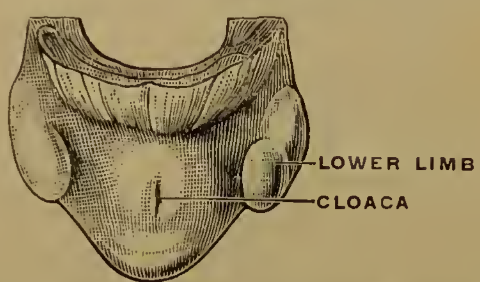


FIG. 115.—External view of the cloaca. (Hertwig.)

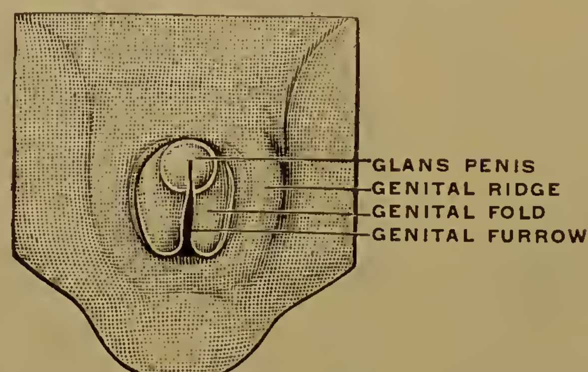


FIG. 116.—Anlage of the penis or clitoris. (Hertwig.)

ing gradually thicker, the dorsal portion, representing the lowermost part of the rectum, becomes separated from the ventral portion, the region intervening between the two being the *perineum* (Fig. 117).

In the mean time, however, on each side of the urogenital opening a ridge of skin, the anlage of the scrotum in the male and the labia majora of the female, has appeared, and between the anterior (ventral) ends of the ridges a tubercle develops, along whose posterior surface a groove is formed which opens proximally into the urogenital sinus. This tubercle is the anlage of the *penis* or *clitoris* (Fig. 116), and at this stage there is practically no difference between the male and female genitalia. In the male the lips of the penial groove now meet together and fuse, the groove being thereby converted into a canal continuous with the urogenital sinus, the canal and sinus together constituting what is

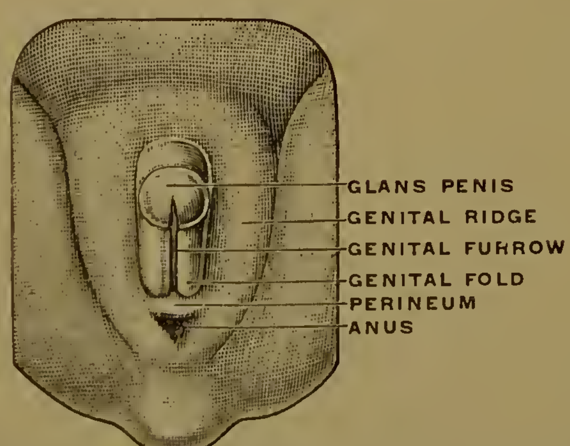


FIG. 117.—Formation of the perineum, separating the alimentary and the genito-urinary passages. (Hertwig.)

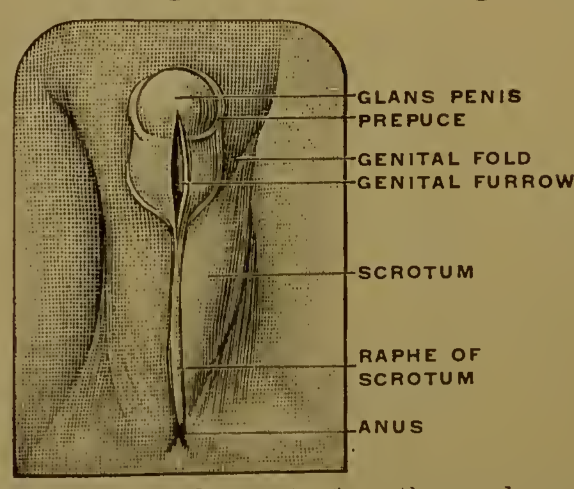


FIG. 118.—Development of urethra and scrotum. (Hertwig.)

termed the *urethra* of the adult. As a result of this closure of the groove the scrotal ridges of either side are brought into contact, and fuse together below the penis to form the adult *scrotum* (Fig. 118). In the female the lips

of the groove on the clitoris do not fuse, but become greatly enlarged and form the *labia minora*, and the *labia majora* remain separated by a depression into which the urethra, developed in this case from the urogenital sinus alone, and the *vagina* open (Fig. 119). The final arrangement of the female external

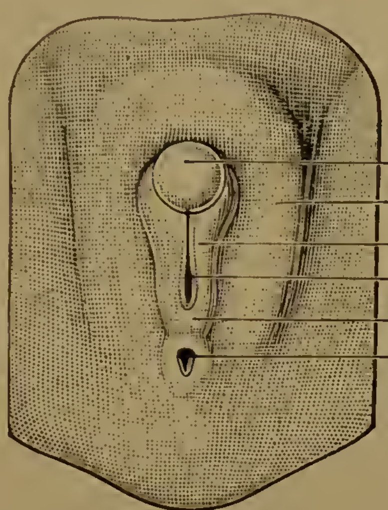


Fig. 119.—Development of vagina. (Hertwig.)

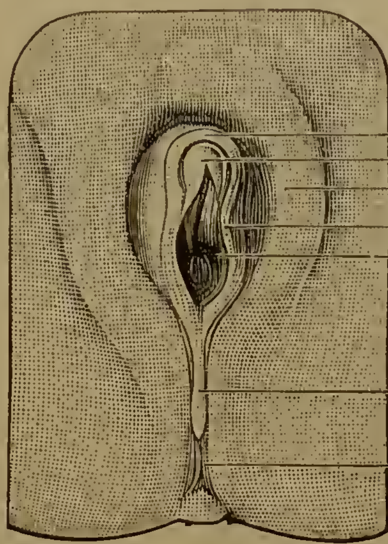


Fig. 120.—Development of the female external genitals. (Hertwig.)

genitalia may thus be readily compared with an early stage of development of the male organs, the latter undergoing a greater amount of differentiation than those of the female.

ORGANS DERIVED FROM THE ECTODERM.

Of the ectoderm the derivatives are the outer layers of the skin and its appendages—hairs, nails, sudoriparous, sebaceous, and mammary glands—and the nervous system and sense-organs. Of the former a detailed account is unnecessary here, but the nervous system requires due consideration.

The Nervous System.

As has been seen, the central nervous system makes its appearance as the medullary groove. As development proceeds the lips of the groove gradually come together, and eventually fuse, transforming the groove into the medullary canal, broader in front than behind, and running the entire length of the body. The cavity of the canal becomes the *central canal of the spinal cord* and the *ventricles of the brain*, while its walls become converted into the various parts of the central nervous system.

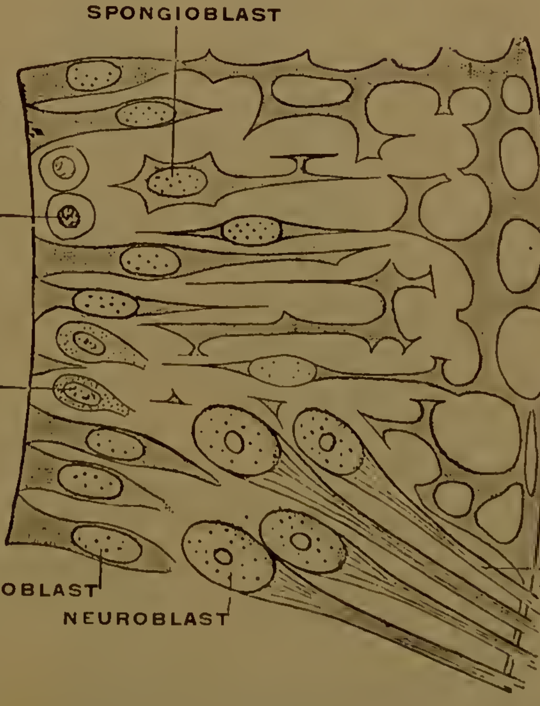


Fig. 121.—Development of nerve-cells and neuroglia-cells in wall of the medullary canal. (Testut and His.)

At first the cells composing the walls of the canal are practically similar, but later certain of them, the *neuroblasts*, lying nearer the central canal, begin to proliferate rapidly, forming *nerve-cells* (Fig. 121), while the remainder, the *spongioblasts*, scatter themselves among the nerve-cells and become the *neuroglia*, some of them eventually coming to line the central canal and forming the *ependyma* (*endyma*). The walls of the canal also become of unequal thickness, the portions in the dorsal and ventral mid-lines becoming thin and forming

respectively the *roof-plate* and the *floor-plate*, while each of the lateral thicker portions becomes divided by a longitudinal groove into a *dorsal* and a *ventral zone*.

The spinal cord develops from the narrower posterior portion of the medullary canal, and is formed mainly by the growth of the cells of the ventral zones, the dorsal zones being represented only by the dorsal horns of the gray matter, while the parts contributed by the roof- and floor-plates are comparatively insignificant. At an early period a series of constrictions, separated from one another by definite intervals, appear throughout its entire length, and give it the appearance of being composed of a series of segments, which are termed *neuromeres*, and to each of which a pair of nerves corresponds. The existence of the constrictions is, however, transitory, and it is probable that their appearance is related to the occurrence of the mesodermal somites.

Up to the end of the third month the cord is practically as long as the spinal canal, but later the canal grows in length more rapidly than the cord, so that the latter becomes relatively shorter, though actually it elongates. As a result of this unequal growth, the nerves which pass out between the lower vertebræ must lengthen, and so the bunch of nerves termed the *cauda equina* is formed. The *motor nerves* arise from cells situated in the ventral horn of the cord, and grow out toward the muscles for which they are destined; the *sensory nerves*, however, arise from a series of thickenings situated just external to the lips of the medullary groove, which, on the closure of the groove, separate from the ectoderm and sink down into the mesoderm. From each cell of these thickenings, which are the *dorsal root-ganglia*, two processes are sent off, one of which penetrates the substance of the cord, while the other extends peripherally. There is thus a fundamental distinction between the motor and the sensory nerve-fibres, the former always growing out from the central system, while the latter arise externally to the cord and brain, and grow inward toward them.

In the anterior portion of the medullary canal, from which the brain develops, neuromeres are present as in the cord; but, in addition, two more distinctly marked constrictions appear and divide the brain into three primary vesicles. The roof-plate of the most posterior vesicle forms a thin roof to the cavity of the vesicle (Fig. 122), which broadens out to form the *fourth ventricle*, a transverse thickening, however, developing in the more anterior part of the roof, and later enlarging to form the *cerebellum*. In the posterior part of the vesicle the dorsal and ventral zones become well developed, forming the *medulla oblongata*, while anteriorly fibres grow downward on each side from the cerebellum toward the ventral mid-line, forming the *pons*. In consequence, it is customary to regard the third vesicle as being secondarily divided into two vesicles, the posterior of which is termed the afterbrain, or *metencephalon* (myelencephalon), while the anterior, which includes the cerebellum and pons, is known as the hindbrain, or *epencephalon*.

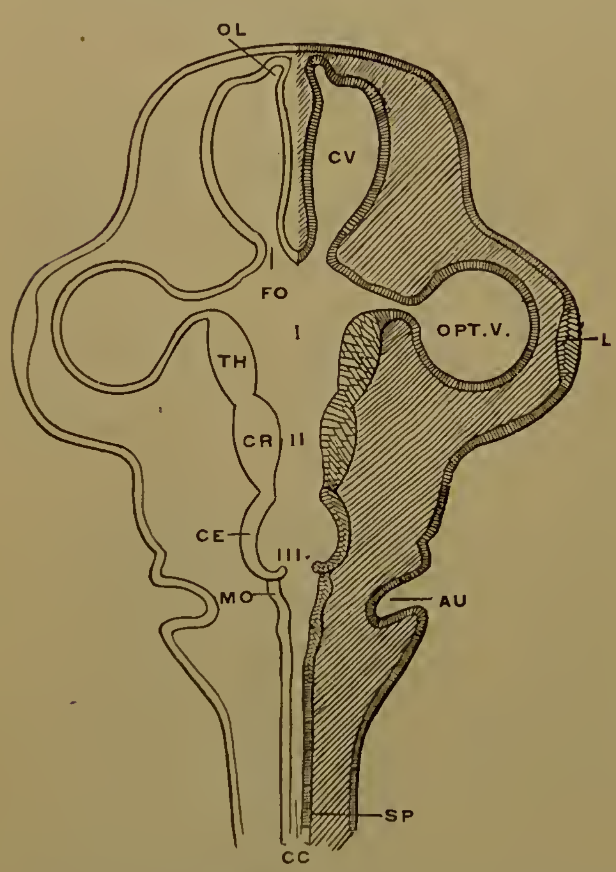


FIG. 122.—Diagram of the brain at an early stage of development: *I*, cavity of primary prosencephalon; *II*, cavity of mesencephalon; *III*, cavity of epencephalon; *AU*, auditory pit; *CC*, central canal of spinal cord; *CE*, cerebellum; *CR*, crura cerebri and quadrigemina; *CV*, cerebral vesicle; *FO*, foramen of Monro; *MO*, medulla oblongata; *OL*, olfactory lobe; *OPT. V.*, optic vesicle; *SP*, spinal cord; *TH*, thalamus opticus. (Martin.)

The cavity of the middle vesicle does not increase in size as rapidly as the others, but assumes the form of a canal, and is termed the *iter* or *aqueduct*. The roof-plate retains its primitive slight development, the dorsal zones, however, giving rise to four well-marked thickenings, the *corpora*

quadrigemina, while the ventral zones become modified to form the *crura cerebri.* To this differentiated middle vesicle is given the name of the mid-brain, or *mesencephalon* (Fig. 123).

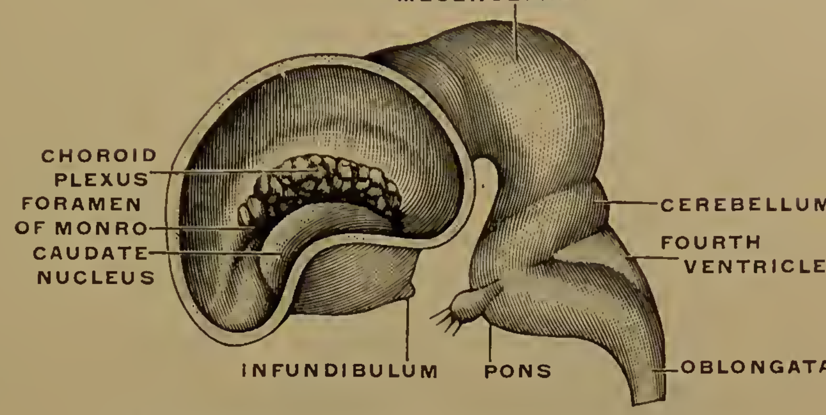


Fig. 123.—Brain of embryo, side view. (Mihalcovics.)

The anterior vesicle undergoes greater changes than either of the others. First, from the lower part of its lateral walls two pouches grow out, finally come into contact with the ectoderm of the sides of the head, and form the optic vesicle (Fig. 122), and later a constriction of the original wall of the vesicle appears, the vesicle thus becoming divided into two portions, the anterior of which, growing most rapidly on each side of the median line, eventually gives rise to the cerebral hemispheres, which are together termed the fore-brain, or *prosencephalon,* while the median portion, together with the entire posterior portion of the original vesicle, forms the 'tween-brain, or *thalamencephalon,* which contains the *third ventricle.*

The anterior wall of the third ventricle is evidently, since the hemispheres are lateral outgrowths, the front wall of the primitive brain, and it constitutes the *lamina terminalis* of the adult. The greater portion of the roof of the third ventricle becomes reduced to a thin layer of cells, which, together with the pia, which lies immediately above it, forms the *velum interpositum,* while more posteriorly an evagination of the roof produces a stalk surmounted by a solid oval body, the *epiphysis,* or pineal body, which comparative anatomy shows to be the rudiment of an unpaired, median eye. In the floor of the ventricle there is to be found, in addition to the optic stalks, a hollow, funnel-like downgrowth, the *infundibulum,* which ends in a solid body, the *hypophysis,* or pituitary body, formed partly by a dilatation of the extremity of the infundibulum, and partly by a mass of tissue which arises as an upgrowth from the roof of the mouth, from which it becomes separated; and lastly, in each of the lateral walls of the ventricle there is to be found an oval thickening, the *optic thalamus* (Fig. 122), developed from the dorsal zone, the subthalamic tissues being the product of the ventral zones.

Since the cerebral hemispheres develop as lateral enlargements of the anterior of the two secondary portions of the vesicle, and since this portion contains a cavity (a part of the third ventricle), it is clear that each hemisphere will contain a lateral prolongation of this cavity, a *lateral ventricle,* and that each lateral ventricle will communicate with the sides of the anterior end of the third ventricle, this communication being the *foramen of Monro.* The hemispheres are, strictly speaking, excessive developments of the dorsal zones of the anterior vesicle, and there occurs in the wall of each of them a thickening, termed the *corpus striatum,* which is continuous behind with the optic thalamus. As the hemispheres continue to develop they project in front of the lamina terminalis and overlap behind the roof and sides of the 'tween- and mid-brains; and the lateral ventricles, increasing in size *pari passu* with the growth of the hemispheres, become prolonged into anterior, posterior, and lateral horns. Into the outer layers of the hemispheres an immigration of cells occurs, the cerebral cortex being thus formed, and during the earlier months of development division of these cells occurs with considerable rapidity, gradually becoming rarer, however, until some time before birth, when it completely ceases, there being, in all probability, no normal increase in the number of cells forming the cerebral cortex after birth.

At about the fourth week of development a finger-like dilatation forms on the anterior part of the under surface of each cerebral hemisphere, a prolongation from the lateral ventricle of the same side passing into it. Anteriorly, the dila-

tations fuse with the olfactory ganglia, to which the olfactory nerves pass from the mucous membrane of the nasal cavity, and they form the *olfactory lobes*, or *rhinencephalon*, the cavities which they contain becoming obliterated before adult life is attained.

Up to the fifth month of development the surface of the hemispheres is smooth, but at this time a depression appears at the side of each hemisphere (Fig. 124) involving that portion of the cortex which lies immediately external to the corpus striatum; this is the *Sylvian depression*. Later the lips of the depression grow toward each other, the upper one growing more rapidly and forming a distinct fold, the *operculum*, which covers in the floor of the depression. This covered portion of the cortex is the *insula* of descriptive anatomy, the fissure between the edge of the operculum and the lower lip of the depression being the *Sylvian fissure*. In the subsequent months of development additional fissures appear, some of which are of sufficient depth to form elevations projecting into the cavities of the lateral ventricles, the *hippocampus* of the middle horn and the *calcar* of the posterior horn being formed in this manner.

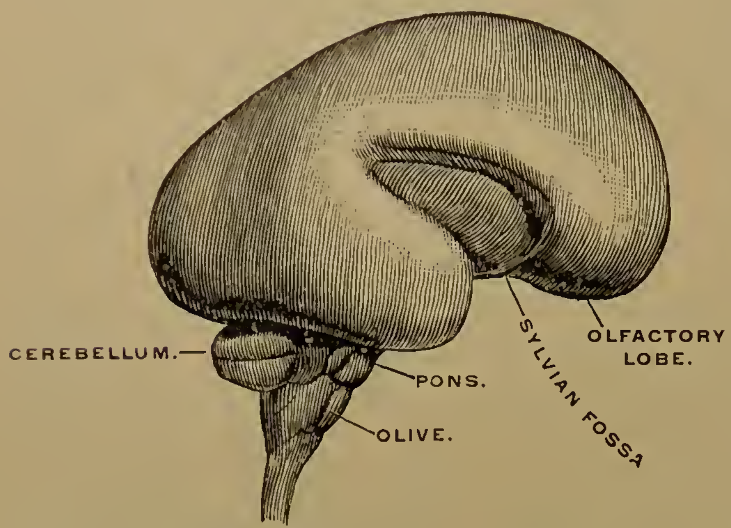


FIG. 124.—Brain of six-months' human embryo, natural size. (Kölliker.)

The lamina terminalis, as has been seen, forms the front wall of the third ventricle, and accordingly connects the two cerebral hemispheres in front. Its lower part remains relatively thin, but above it becomes much thickened from before backward, the thickening having a triangular shape. In the thickening a slit-like cavity appears, and through that portion of the thickening which forms the roof of the cavity nerve-fibres pass across from the cortex of each cerebral hemisphere to that of the other, forming the *corpus callosum*, while in the floor of the cavity longitudinal fibres develop, forming the pillars of the *fornix*. The cavity itself is the so-called *fifth ventricle*, its lateral walls being the *septum lucidum*, and it is evident from its mode of development that it cannot be considered homologous with the other ventricles of the brain.

One other set of structures require notice here, though they are not actual constituents of the central nervous system. These are the *choroid plexuses*, which consist of collections of blood-vessels developed in the pia over certain portions of the brain where the walls are exceedingly thin—as, for instance, over the roof of the third and fourth ventricles and along the floor of the lateral ventricles. The vessels push these thin membranes in front of them into the interior of the brain, and thus come to lie apparently in the interior of the ventricles, though in reality they are separated from them by the prolongation of the roof or floor which they carry in front of them.

The Sympathetic System.—The sympathetic ganglia have usually been regarded as formed by a proliferation of cells from the anlagen of the dorsal root-ganglia, and as being, therefore, of ectodermal origin. More recent observations tend to assign them to the mesenchyme, their first indication being found in a cord of cells in the mesenchyme just external to the dorsal aorta. The history of the system needs further study, however, before definite statements can be made concerning it.

The Olfactory, Gustatory, and Tactile Organs.—Of the organs of special sense the tactile and gustatory are not as yet thoroughly understood embryologically. The olfactory organ appears as two circular thickenings of the ectoderm, one on each side of the fronto-nasal process, just in front of the mouth, and these, sinking beneath the surface, come to form the floor of a pair of depressions (Fig. 99)

whose lips, gradually approaching, finally fuse, except below, to form a pair of cavities, the openings into which are the *anterior nares.* These at first communicate with the mouth, but become separated from it by the union of the two maxillary processes, a separation further perfected by the formation of the hard palate.

The Eye.—The first indications of the eye are a pair of hollow outgrowths from the anterior vesicle of the brain (Fig. 122), and these take the form of vesicles in contact with the ectoderm externally and united to the 'tween-brain by narrow optic stalks. That portion of the wall of each vesicle which is in contact with the ectoderm becomes invaginated, and the vesicle thus becomes converted into a double-walled cup, from whose walls the *retina* is formed. The invagination proceeds more rapidly on the under side of the vesicle, and is continued backward some distance on the optic stalk, which thus becomes grooved on its under surface, the optic cup being imperfect along a narrow line on its under surface, this opening being the *choroidal fissure* (Fig. 125). When the retina is established nerve-fibres grow from its cells toward the brain, choosing the optic stalk as the path of least resistance, and thus converting it into the solid *optic nerve.*

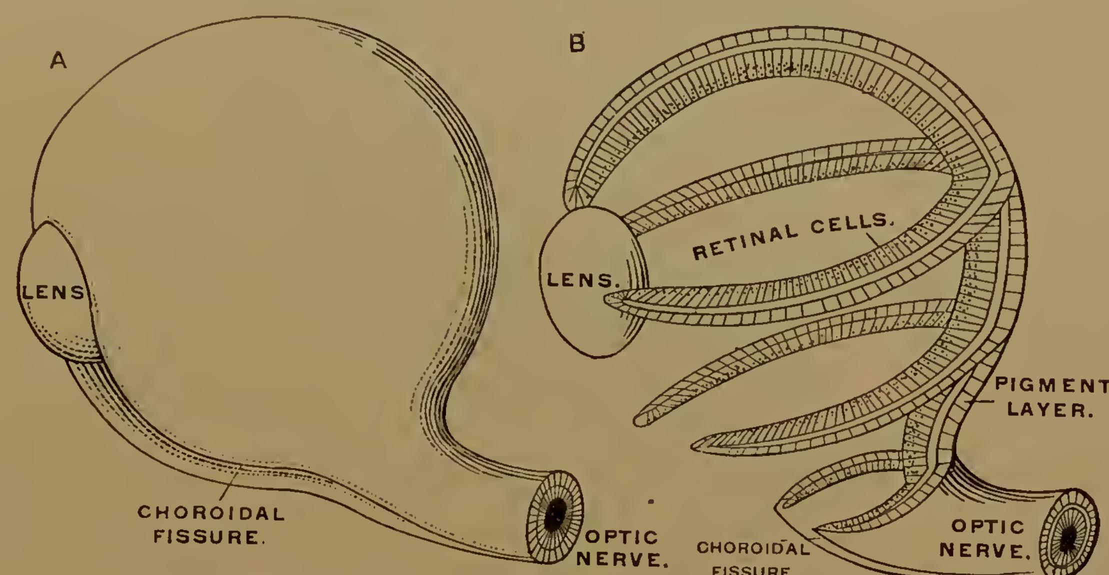


FIG. 125.—Diagrams of the formation of the optic cup and choroidal fissure.

That portion of the surface ectoderm with which the optic vesicle came in contact early begins to thicken, and later becomes invaginated, pressing upon the wall of the vesicle. This ectoderm gradually separates from the surface and forms a spherical, hollow structure, lying in the mouth of the optic cup; it is the anlage of the *lens* (Fig. 126). Later, the cells of its anterior wall flatten down to form the epithelium of the lens (Fig. 127), while those of the posterior wall become much elongated, and are converted into fibres running in various directions and completely filling the original cavity. At first the lens is in close contact with the surface ectoderm; but later mesenchymal tissue pushes in between it and the ectoderm, forming a layer which becomes converted into the *cornea* (Fig. 127), the ectoderm external to it forming the *conjunctiva.* At the same time a concentration of mesenchyme takes place all around the optic cup to form the *sclerotic* and *choroid coats* of the eyeball, and between the outer surface of the lens and the cornea fluid collects, forming the *aqueous humor.* The *vitreous body* is formed by the migration of mesenchyme into the interior of the optic cup through the choroid fissure, and is at first richly supplied with blood, the artery bringing it running along the groove on the under surface of the optic stalk, and so entering the choroid fissure. In the later

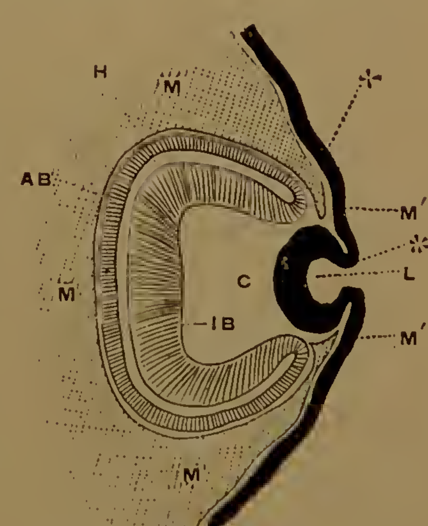


FIG. 126.—Semi-diagram of the secondary optic vesicle and the developing lens: *AB*, layer which becomes pigmentary retinal layer; *C*, posterior chamber, to be occupied by vitreous; *H*, remnant of cavity of primary optic vesicle; *IB*, layer which becomes greater part of retina; *L*, lens, as a cup open on exterior; *M, M, M*, mesoderm; *M'*, *M'*, points from which mesoderm grows in to form iris and body of cornea; +, place at which the primary optic vesicle has been doubled back on itself; *, point of invagination of ectoderm to form lens. (Wiedersheim.)

development the choroid fissure closes completely, and the lips of the groove on the stalk also meet and close, the artery thus becoming enclosed by the stalk, and forming the *arteria centralis retinæ* of the adult. Later on, the mesenchyme in

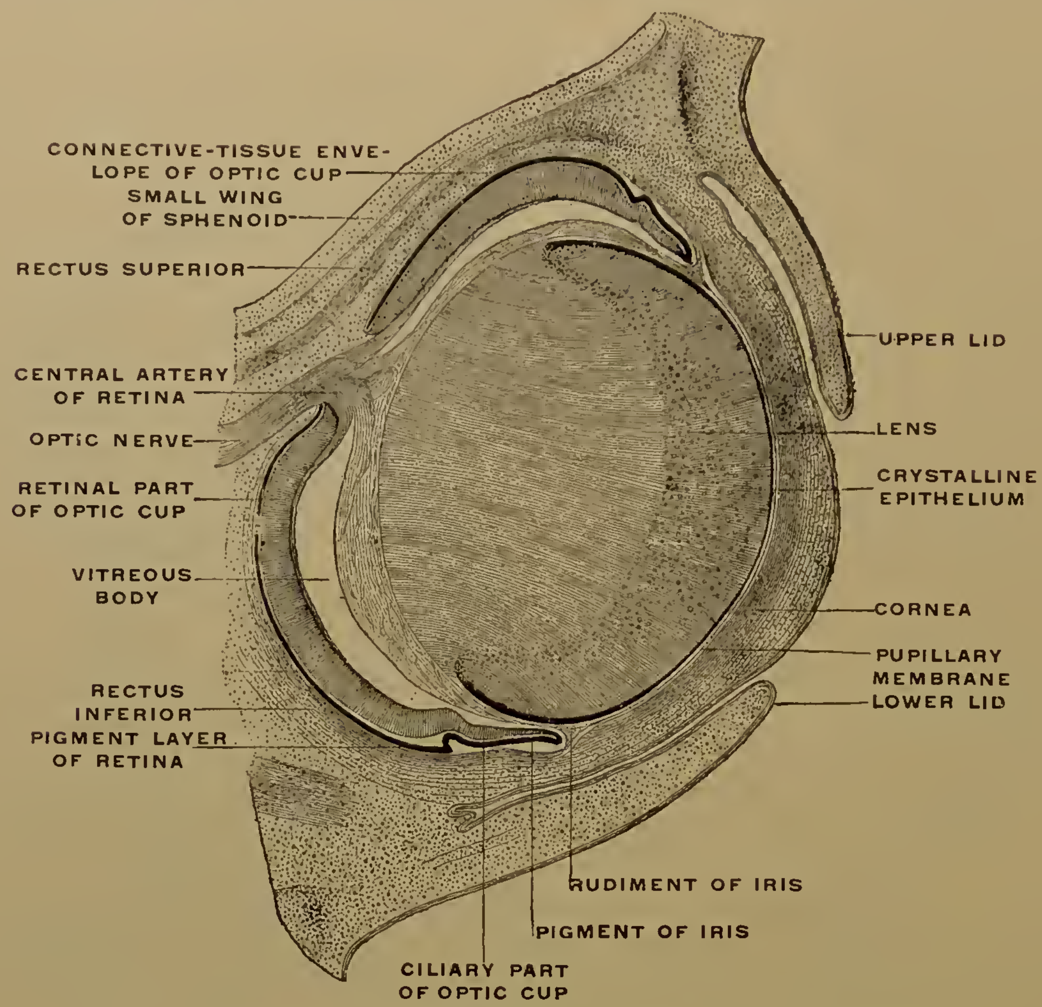


FIG. 127.—Horizontal section of the developing eye. (After Kölliker.)

the interior of the optic cup becomes converted into the peculiar gelatinous tissue of which the vitreous is composed, and its blood-supply becomes cut off, the only trace of the existence of the artery in front of the retina being the space originally occupied by the artery, persisting as a canal traversing the centre of the vitreous, and known as the *hyaloid canal.* When the blood-supply of the vitreous is at its highest development it extends as far forward as the lens, which it surrounds with a vascular capsule, which later normally disappears completely.

Of the structures accessory to the eye, the *eyelids* develop as folds of skin, which grow together over the eye, and remain fused together until shortly before birth. The *lachrymal glands* are formed as solid ingrowths (later becoming hollow) from the conjunctiva, just at the point where the upper-eyelid folds arise, while the *lachrymal duct* is developed as a thickening of the ectoderm, which forms the floor of the groove found at an early stage between the fronto-nasal and the maxillary processes. This thickening later becomes hollowed out, and the lips of the groove meet over the canal so formed, completely enclosing it, and, as the nasal cavity differentiates, the lower end of the duct comes to communicate with it.

The Auditory Organ.—The *membranous labyrinth* or inner ear is the first portion of the auditory organ to develop, appearing as a circular depression of the ectoderm over the first visceral cleft (Fig. 122). This auditory pit deepens, sinking down into the subjacent mesenchyme, its floor at the same time thickening, and it eventually becomes constricted off from the ectoderm as a completely closed sac, a small process from one side of this representing the remains of its connection with the surface, and forming the *ductus endolymphaticus.* From the ventral wall of the sac a tubular outgrowth forms, which is the anlage of the *cochlea,* and in the angle between this and the sac proper is to be found the *auditory ganglion,* which had previously formed as a thickening of the ectoderm

near the auditory pit, and had migrated into the subjacent mesenchyme. A constriction now begins to form in the inner wall of the sac (Fig. 129), dividing it into an upper and a lower portion; and from the upper portion two flat hollow disc-like outgrowths develop, one of which lies in a horizontal plane, while the other is directed vertically, but is bent so that the anterior half of it lies almost at right angles with the posterior. These are the anlagen of the *semicircular canals* (Fig. 130), which are finally formed from the edges of the discs, the central portion of the horizontal disc and of each half of the vertical one disappearing, so that three canals are formed, each opening at both extremities into the upper portion of the auditory sac. At one end of each canal a widening occurs, and, from the mode of development just outlined, it will be seen that the two vertical canals will be united together at one end to form a common canal before opening into the sac (Fig. 131). The constriction of the wall of the sac deepens gradually, until finally the upper portion, or *utriculus*, communicates with the lower portion, or *sacculus*, only by a slender canal, which represents that portion of the original sac with which the ductus endolymphaticus communicates. While these processes have been going on, a second constriction has formed between the cochlear anlage and the sacculus, whereby the connection of these two parts is also reduced to a slender canal, the *canalis reuniens*. In correspondence with this division of the original sac a division of the auditory ganglion also occurs, one portion of it, the *vestibular*

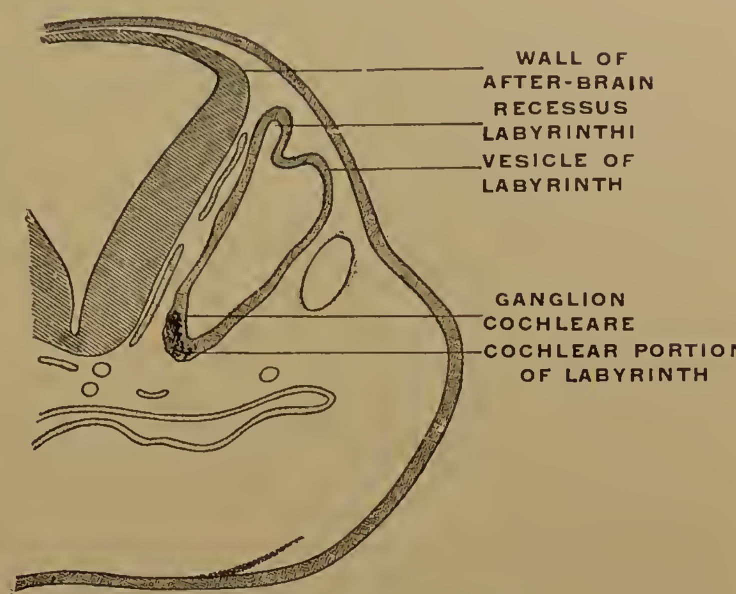


Fig. 128.—Section through the auditory vesicle of a sheep embryo. (Hertwig, after Boettcher.)

Fig. 129.—Section through the auditory vesicle of sheep embryo, somewhat older than that in Fig. 128. (Hertwig, after Boettcher.)

ganglion, being in relation to the sensory epithelium of the utriculus, sacculus, and semicircular canals, while the other is drawn out into an elongated band, the *spiral* or *cochlear ganglion*, which follows the coils into which the cochlea becomes thrown, and stands in relation to the *organ of Corti*, which develops from the cochlear epithelium.

In the mean time, a condensation of the mesenchyme surrounding each audi-

tory sac has been taking place, and the portions of the tissue immediately in contact with the walls of the sac become converted into fibrous connective tissue, and so strengthen the walls of the membranous ear, while the outermost portions become converted into cartilage, and later into bone, forming the periotic capsule, in whose walls, however, three membranous areas are left, one of these being where a canal, the *ductus perilymphaticus,* leads from the perilymphatic space to the surface of the bone. Between the inner wall of the capsule (which is composed of dense bone, and forms what is termed the *osseous labyrinth*) and the connective tissue a layer of the mesenchyme is left in the form of a loose connective tissue, which subsequently degenerates, leaving a space, which becomes filled with fluid, around the membranous ear. This is the *perilymphatic space,* which, in the cochlea, is separated into two parts by the membranous cochlea, being attached on either side to its wall, so that a section of any coil of the cochlea will show the membranous cochlea, known in anatomy as the *scala media,* with a perilymphatic space above it, the *scala vestibuli,* and another below it, the *scala tympani,* these two spaces communicating, however, at the apex of the cochlea.

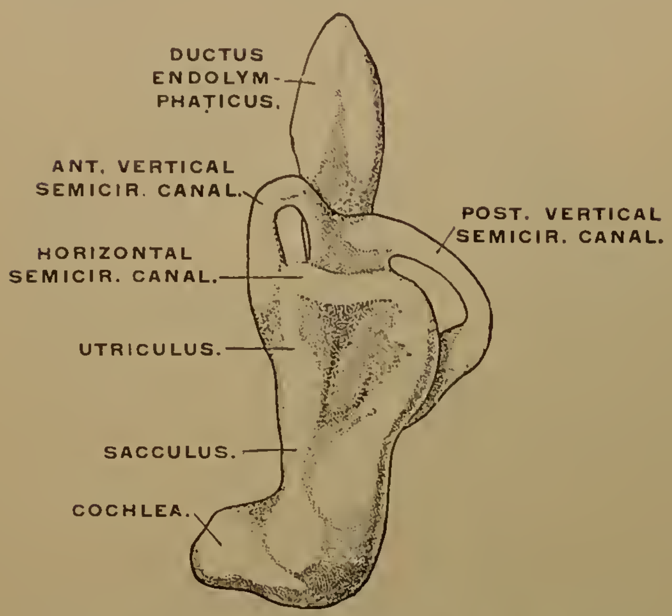


FIG. 130.—Model of internal ear of human embryo of about five weeks. (C. S. Minot, after W. His, Jr.)

The middle ear is the remains of the first visceral cleft, the groove on the wall of the pharynx which represents the cleft becoming converted into a canal

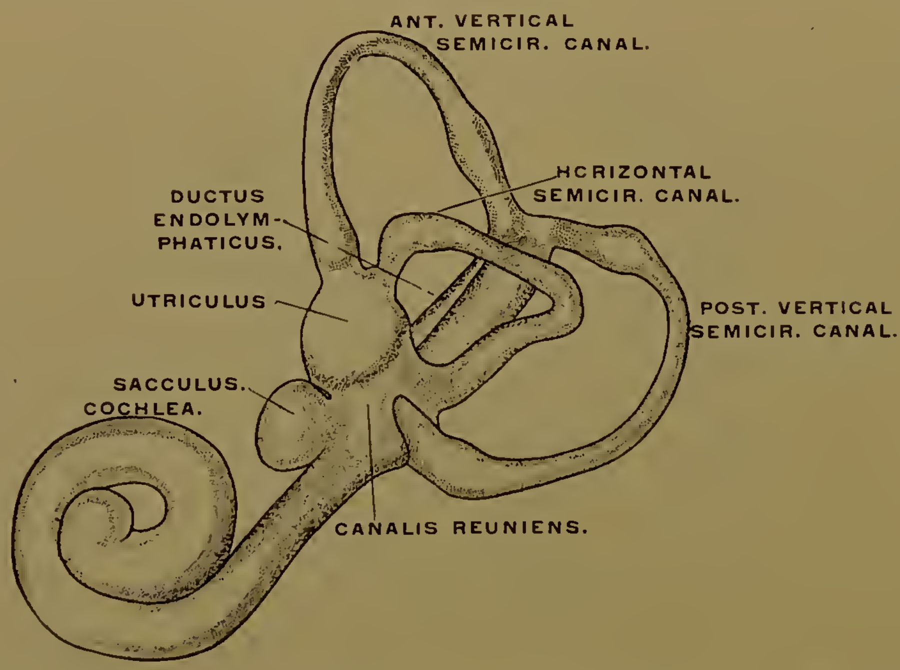


FIG. 131.—Model of internal ear of human embryo of about two months. (C. S. Minot, after W. His, Jr.)

by the fusion of its lips, the upper end of this canal being enlarged to form a cavity, the *tympanic cavity,* while the rest of it forms the *Eustachian canal,* which opens below into the pharynx. The tympanic cavity is, however, up to birth exceedingly narrow, practically merely a slit, its walls, beneath the mucous membrane lining it, being largely composed of a loose gelatinous tissue, in which lie imbedded three small bones, the *malleus, stapes,* and *incus.* The upper end of Meckel's cartilage, which develops, as has been seen, in the first branchial arch, separates from the lower portion, and forms two small bones, which are imbedded in the front wall of the tympanum, and are the malleus and incus; while the stapes seems to be produced by the fusion of two distinct parts. Its flat portion,

which rests in one of the three unossified spots of the osseous capsule of the internal ear, the *foramen ovale*, seems to be really the portion of the wall of the capsule which should fill this foramen, the mesenchyme immediately around it having remained membranous, while its arch is the ossified upper end of the cartilage of the second branchial arch. These bones are at first imbedded in the gelatinous tissue of the wall of the tympanic cavity. After birth, air is taken into this cavity through the Eustachian tube, and the cavity enlarges, pressing aside the gelatinous tissue and surrounding bones, which thus form a chain extending from the tympanic membrane to the foramen ovale, and apparently passing through the middle of the tympanic cavity, though in reality they are enclosed by the mucous membrane which lines the cavity.

Two of the three unossified spaces in the wall of the osseous capsule of the inner ear have been accounted for in the ductus perilymphaticus and the foramen ovale; the third opening is the *foramen rotundum*, which is closed by a membrane on which the scala tympani abuts. The outer wall of the tympanic cavity is formed by the *tympanic membrane*, and is at first thick with the gelatinous tissue which encloses the auditory ossicles, it being only after birth that it is reduced to the thin membrane found in the adult. It is formed partly by the partition between the external and internal grooves of the first branchial cleft, and partly by the upper ends of the first and second branchial arches.

Just as the inner groove of the first branchial cleft forms the Eustachian tube and tympanum, so the upper end of the outer groove of the same cleft forms the outer ear, the *pinna* developing from elevations appearing on the first and second visceral arches in the vicinity of the persistent part of the groove.

THE BONES.

By GEORGE WOOLSEY.

THE adult human skeleton consists of a number[1] of *bones*, with a small amount of *cartilage* in some parts, where they are joined or articulated with one another. The bones, as they are generally studied after maceration and drying, are composed of mineral or earthy salts, principally phosphate and carbonate of lime.[2] The soft organic parts, of which a prepared bone is deprived, consist partly of the fibrous and vascular *periosteum*, which covers the surface and is continuous with the connecting ligaments, and the *medulla* or marrow, which fills the internal cavities, and partly of the tough, flexible, animal matter, which retains the shape of the bone when the earthy matter is removed.

The main *functions* of bones are to afford a solid framework, to support softer parts, to protect delicate organs, and to serve for the attachment and leverage of muscles which produce the different movements. To serve these different purposes bones must differ in their *outward form*, according to which we distinguish—(1) *Long bones*, consisting of a shaft or diaphysis and two expanded extremities or epiphyses, as in the limbs. They afford support and leverage for motion, and are usually somewhat curved in one or two directions, thus securing greater elasticity and strength; (2) *Flat bones*, as in the pelvis, scapula, and the roof of the skull, affording protection and support to the contained parts, and also muscular attachment; (3) *Short bones*, as in the wrist and ankle, where strength combined with free motion is required; (4) *Irregular* or *mixed bones*, like the vertebræ and many of the bones of the skull.

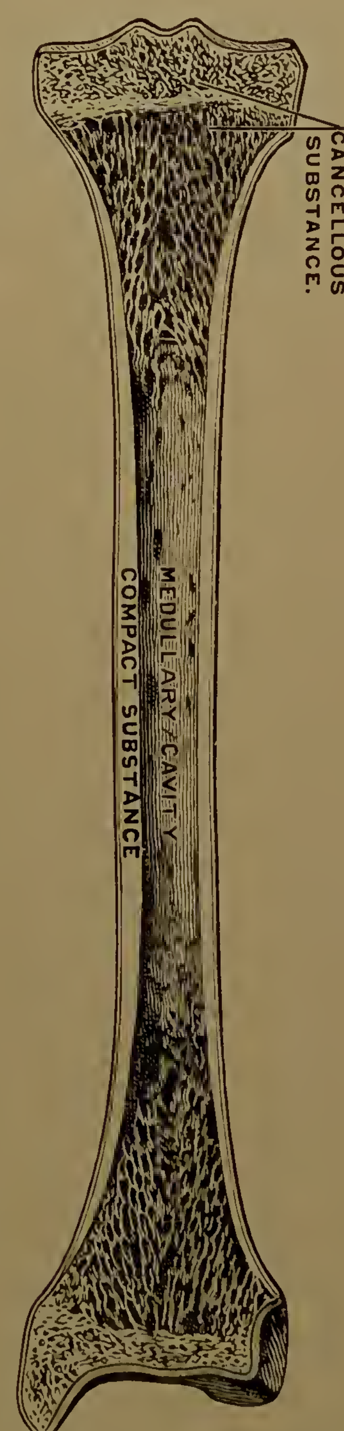


Fig. 132.—The longitudinal section of a long bone.

Internal Arrangement.—On longitudinal section of a long bone (Fig. 132) notice that there is an outer layer of hard, *compact substance*, varying in thickness and enclosing a central or *medullary cavity*, in the shaft of the bone, and porous, spongy or *cancellous* bony tissue at the extremities. In the recent state the medullary cavity is filled with yellow or *fatty marrow*, and the cavities of the cancellous tissue with *red marrow*. Short, flat, and irregular bones have an outer layer of compact substance, enclosing cancellous tissue containing red marrow. The cancellous tissue at the ends of long bones and in other bones bearing pressure is so arranged that its bony lamellæ are principally directed in the lines of pressure or of muscular tension. The porosity or hollowness of bones serves to combine requisite size and strength with lightness.

Development of Bones.—In the early embryo the bones are preformed either

[1] Exclusive of the ossicles of the ears, the teeth, and the Wormian bones, there are 200 bones, of which 64 are in the upper extremity, 62 in the lower, and 74 in the trunk, distributed as follows: the vertebral column 26, the skull 22, the ribs and sternum 25, and the hyoid bone 1.

[2] Respectively 51 per cent. and 11 per cent. of the solids of fresh bone.

in membrane or, in the majority of cases, in cartilage covered by membrane, so that all are possessed of membranes, and ossification beneath membrane is found in all, and exclusively in some.[1] One or more original or *primary centres* appear for each bone, from which ossification proceeds, forming the *diaphysis* ("between-growth") or body. After a varying time one or several *secondary* or *tertiary centres* may appear, which form the *epiphyses* ("upon-growth"), united to the diaphysis for some time by cartilage. Some of these form the extremities of long bones, others projecting processes like the acromion of the scapula or the trochanters of the femur.[2]

Bone formed in cartilage is not adapted to be permanent, for the cartilage is non-vascular, and, further, it is not true bone, but a mere calcification. It is therefore resorbed and replaced by vascular bone from an ossific centre beneath the membrane.

In the long bones the first or primary centre in the shaft appears before birth.[3] Later, one or more secondary centres appear at either end, all but three[4] after birth. The bone-centres in the shaft and extremities of long bones are separated from one another by a layer of cartilage (*epiphyseal cartilage*), which continues to grow at the same time that the bone-centres on either side grow into it. By this means the bone is enabled to increase in length, until first one and then the other cartilage ceases to grow, and the shaft and extremities unite by ossification of the intervening layer of cartilage. Such bones grow in diameter by the deposit of bone beneath the periosteum. Bones in which ossification is begun and completed in membrane, as in the vault of the skull, are enabled to increase in size by the growth of the membrane in the sutures separating them, until they have attained their full size, when this growth stops.

Until the epiphyseal cartilage has ossified separation without bony fracture may occur here. The date of this ossification is therefore of importance in some cases. The bony union of shaft and extremities takes place according to the following rules:

1. The extremity whose ossific centre is the first to appear is the last to unite with the shaft. Exception: the lower end of the fibula, but the upper end is vestigial.
2. The extremity toward which runs the nutrient artery is the first to unite.
3. The nutrient arteries run toward the elbow and away from the knee—*i. e.*, down hill—if elbow and knee both be flexed.
4. Union of the epiphyses and diaphyses of long bones occurs from the sixteenth to the twenty-second year (occasionally twenty-fifth year, tibia), and earlier in the upper than in the lower extremity.
5. When two or more centres of ossification occur in an epiphysis, these unite together before the epiphysis unites with the diaphysis or shaft.

Many bones of the skull are *composite*, or made up of two or more elements, separate in their embryonic development, in young bones, and in the skulls of other vertebrates.

The study of these details and the comparison of the human anatomy with that of other vertebrates, on the basis of their development, constitute the study of *morphology*, in which the most recent and interesting advances in anatomy have been made.

Descriptions of Bones.—The student of osteology should always have the actual bones in his hand as he follows their descriptions, remembering that the latter represent the average of bones, and that it is very rare to meet with a bone in which every detail corresponds to the description.

[1] Ossification commencing in membrane may invade and replace cartilage, as in the clavicle.
[2] Prominent projections not developed from independent centres are called *apophyses*.
[3] Many primary centres of ossification appear after birth, as in the carpal bones.
[4] The adjoining ends of the femur and tibia, and sometimes the head of the humerus.

The surface of young bones is comparatively smooth. The rough lines and ridges on adult bones are due to ossification at the attachments of muscles. Any marked bony prominence may be called a *process* or *apophysis* (" out-growth "); if blunt, a *tuberosity* when large, a *tubercle* when small; if sharp, a *spine* or *spinous process*; if long, a *line* or *ridge*; when narrow, a *crest*; if broad, a *condyle* (" knuckle ") when articular, or a *head* when supported on a constricted part or *neck*. A depression or hollow space in or upon a bone or between several bones is sometimes called a *fossa* (" ditch "). A *glenoid* (" cavity-like ") *fossa* is a shallow articular depression, a *cotyloid* (" cup-like ") *fossa* is a deeper one. *Sinus* and *antrum* are terms applied to cavities within certain bones. A *fissure* is a narrow slit; a *foramen*, a hole or orifice; a *canal* or *meatus*, a long, tube-like passage-way. Other terms used require no explanation.

In describing the different aspects of a bone or other anatomical part the body is supposed to be in the erect position. A surface, extremity, or other part directed toward the head is called *superior*; toward the feet, *inferior*; toward the front, *ventral* or *anterior*; toward the back, *dorsal* or *posterior*. That aspect directed toward the median, vertical, antero-posterior plane of the body is called *internal* or *mesial*; that away from the same plane, *external* or *lateral*.

Certain areas on bones are devoted to the attachment of muscles. Usually each extremity of a muscle is fastened to a bone, the proximal end being called its origin, the distal end its insertion. The muscle is said, therefore, to arise from the one point, and to be inserted into the other; and the bones, respectively, are said to give origin to and insertion to the muscle.

THE SPINE.

The *spine*, or *vertebral column*, is composed of 26 superimposed bones called *vertebræ* (" capable of turning "). The name *spine* is derived from the series of spines or spinous processes which are the most obvious portions of the column of bones in the undissected body. Of these, the upper 24 are *true* or *movable vertebræ*, and are divided from above downward into 7 *cervical*, 12 *thoracic*, and 5 *lumbar*. Of the two lower composite bones comprising the *false vertebræ*, the upper one, or *sacrum*, is formed by the fusion of 5 vertebræ, and the lower one, or *coccyx*, of 4 ankylosed, vestigial, terminal vertebræ, all separate in early life.

A **typical vertebra** consists of a *body* or *centrum* in front, with a *neural arch* behind, which completes the *vertebral* or *spinal foramen*, the series of which forms the *vertebral canal* in which the spinal cord and its membranes are lodged and protected.

The disc-like *body* supports and bears the weight of the head and trunk. Its superior and inferior surfaces are flattened or slightly concave, and rough for the connecting intervertebral discs. The circumference is concave vertically, convex horizontally; but behind it is concave in both directions, where it bounds the vertebral foramen ventrally and presents large foramina for veins.

The *neural arch* is formed of two symmetrical halves, and consists of two pedicles and two laminæ, supporting seven processes—four articular, two transverse, and one spinous.

The *pedicles* (" little feet "), or ventral parts of the arch, consist of two narrow, thick piers of bone, projecting horizontally back from the upper part of the dorsal and external aspect of the body. Above and below the pedicles are the *vertebral notches*, which, with the notches of adjacent vertebræ, form the *intervertebral foramina* for the passage of the spinal nerves and vessels.

The *laminæ*, broad and flat, complete the arch by fusing together in the median line behind. Their upper borders and lower anterior parts are rough for the attachment of the ligamenta subflava.

The *spinous process* projects backward in the median line from the junction of the laminæ, and serves for the attachment of muscles and ligaments.

The *transverse processes* project outward from the junction of the pedicles and laminæ on each side.

The *articular processes* present an upper and a lower pair, extending upward and downward from the roots of the transverse processes, for articulation with the pairs above and below. The articular surfaces of the upper and lower pairs look in opposite directions.

Costal processes, when present, spring from the sides of the body at or near the junction of the latter with the pedicles.

THE CERVICAL GROUP.

The *typical cervical vertebræ* (from the third to the sixth, inclusive) (Fig. 133) are especially characterized by the foramina in the transverse processes. The *centrum,* or *body,* is small, oval, and transversely elongated. Its upper surface is concave transversely, due to the elevation of its lateral margins into lips which articulate with the rounded lateral margins of the lower surface of the vertebra above. The lower ventral margin projects downward, so as to overlap the rounded ventral margin of the upper surface of the vertebra below. The depth of the body is equal in front and behind. The *pedicles* are directed obliquely outward and backward from about midway between the upper and lower borders of the body. The *laminæ* are long, narrow, and more or less flattened from above downward. The *spinous process* is short, bifid at the extremity, and nearly horizontal. The *transverse processes,* directed outward and forward, are seen to be rather short, and their bifid extremities present ventral and dorsal tubercles. The base of each transverse process is perforated by the *costo-transverse foramen,* which transmits the vertebral artery and vein in the upper six vertebræ, and which divides the base into two roots. The dorsal root springs from the junction of the pedicles and laminæ, like the thoracic transverse processes; the ventral root springs from the side of the body, corresponding in position to the vertebral end of a rib. It is a vestigial rib (*costa*), and is called the *costal process.* The superior *articular processes* look upward and somewhat backward, the inferior downward and somewhat forward. The *foramen* is triangular, and larger than in the other regions.

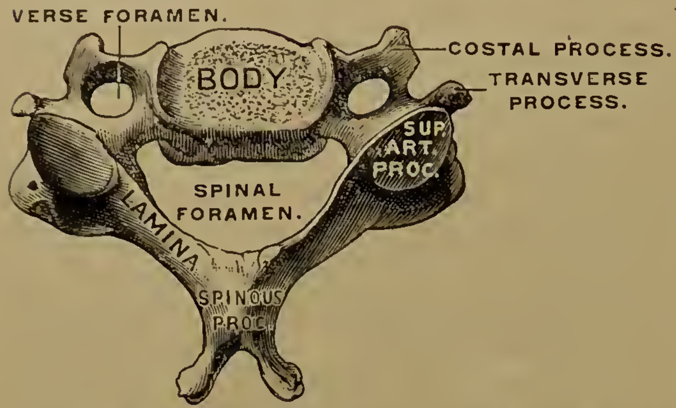


FIG. 133.—Cervical vertebra, viewed from above. (Testut.)

Peculiar Cervical Vertebræ.—These are the first, second, and seventh. The peculiarities of the first and second are such as to allow the freest movement of the head on the spinal column which is consistent with the safety of the spinal cord.

The **atlas** or **first cervical vertebra** (Fig. 134) lacks a body and spinous process, and forms a ring consisting of two *arches,* ventral and dorsal, connecting two *lateral masses.* The *body* has become separated from the atlas and ankylosed to the axis as the odontoid process. The *ventral arch,* one-fifth of the ring, presents in the median line in front a small tubercle for muscular and ligamentous attachment, and behind a circular facet for articulation with the odontoid process. The *dorsal arch,* two-fifths of the ring, has a median tubercle behind, the rudi-

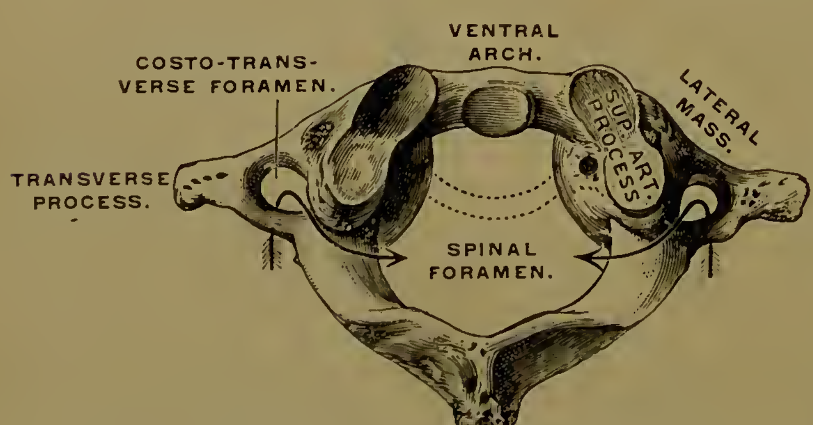


FIG. 134.—The atlas, viewed from above. (Testut.)

ment of a spinous process, which, if present, would interfere with the rotation between the atlas and axis. On its upper surface, at the junction with the lateral mass, is a deep groove, sometimes a foramen, for the passage of the vertebral artery and the first spinal nerve. The groove or notch on its under surface, for the second spinal nerve, is also behind the articular process, while the lower spinal nerves pass out in front of the articular processes. The *lateral masses* present above two oval, elongated, articular surfaces looking upward and inward, and diverging behind. These articulate with the condyles of the occipital bone and permit the nodding movements of the head. Transverse grooves may divide these surfaces in two or give them a kidney-shaped outline. The inferior articular processes, or the facets on the under surface of the lateral masses, are nearly flat and circular, looking downward and slightly inward. Their articulation with the axis permits the rotatory movements of the head. On the inner surface of each lateral mass, between the two articular processes, is a tubercle for the transverse ligament, which divides the interior of the ring into a smaller ventral segment for the odontoid process and a larger dorsal segment, the spinal foramen, for the spinal cord. The transverse processes are long, serve for the leverage of the rotator muscles of the head, and are to be felt below the mastoid process of the temporal bone. The foramen in them is large, their costal processes are slender, and their extremities broad and not bifid.

The **axis or second vertebra** (*vertebra dentata*, "toothed vertebra") (Figs. 135, 136) has a large, strong body, surmounted by the *odontoid* ("tooth-like") *process*,

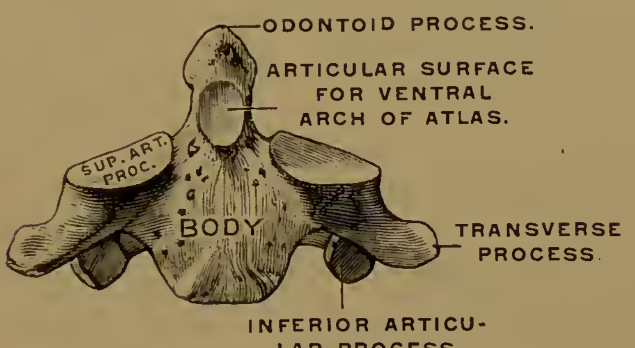


FIG. 135.—The axis, front view. (Testut.)

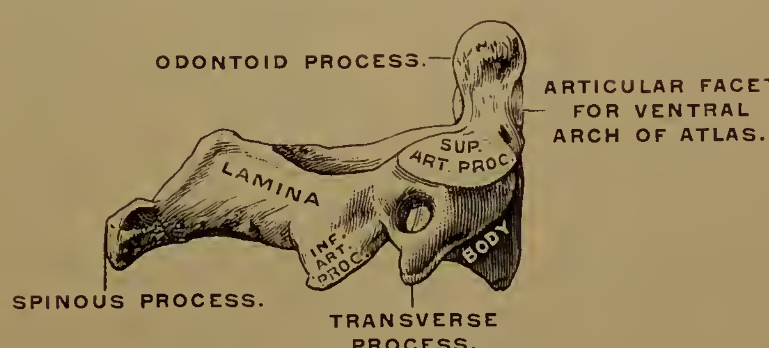


FIG. 136.—The axis, its right side. (Testut.)

on which as a pivot the atlas rotates, carrying with it the head. This process has in front a smooth surface for articulation with the atlas, and behind, at a slightly lower level, a smooth groove, which forms a constriction, the neck, and receives the transverse ligament. The lower surface of the body is like that of the typical cervical vertebra, except that the overlapping lip is more prominent. In front the body presents a vertical median ridge and two lateral depressions. The pedicles are stout, and partly on them, partly on the body, rest the oval superior articular surfaces, close to the base of the odontoid process, and directed upward and slightly outward. The weight of the head is transmitted to these surfaces through the lateral masses of the atlas, and from them it passes largely to the body and less to the inferior articular processes of the axis through a strong arch, the piers of which are the body and the inferior articular processes. From this point down the weight is borne mostly by the bodies. The inferior articular processes resemble those of the vertebræ below in form, position, and direction. The spinous process is strong, deeply bifid, and grooved below. It gives attachment to muscles which rotate the head. The transverse processes are short. The costal processes are thick at their bases, and the anterior tubercles are very rudimentary. The foramina for the vertebral arteries are directed obliquely upward and outward toward those in the atlas.

The **seventh cervical vertebra** is called the *vertebra prominens*, from the length of its spinous process, which is a landmark readily felt beneath the skin. This is not bifid, and it gives attachment to the ligamentum nuchæ. The costal processes and their anterior tubercles are small, but sometimes are larger and segmented off as cervical ribs. The costo-transverse foramen is small. The transverse processes are large.

The spinous process of the *sixth cervical vertebra* is occasionally so long as to be mistaken for that of the seventh, and the anterior tubercle of its transverse process is called the *carotid tubercle*, as against it the carotid artery may be compressed.

THE THORACIC GROUP.

The *thoracic vertebræ* (Figs. 137–139) are typically characterized by the presence of articular facets on the bodies and transverse processes, for articulation with the ribs which they support. The disc-like *body*, or *centrum*, is oval or heart-shaped, only slightly wider transversely than from before backward, and deeper behind than in front. Where the body joins the arch two demi-facets are

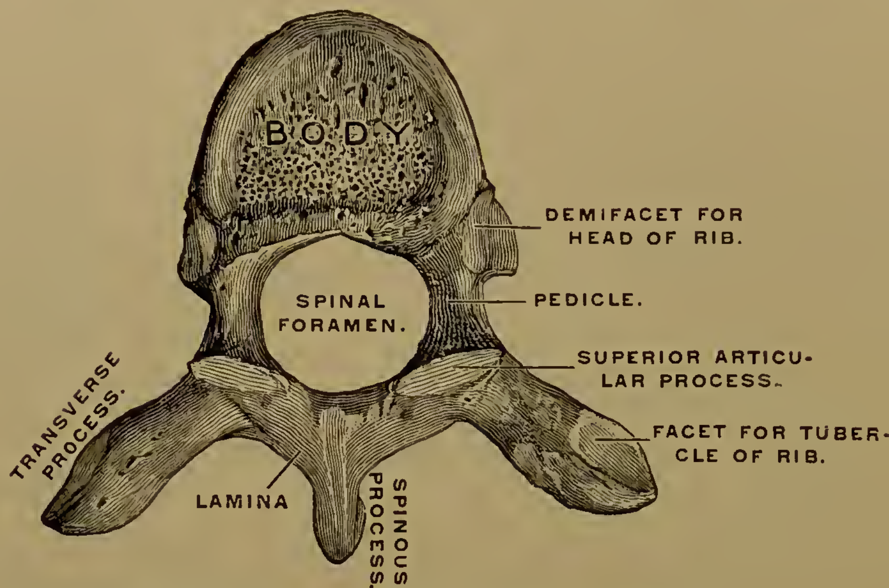


FIG. 137.—A thoracic vertebra, upper surface. (Testut.)

found on either side, one at the upper and one at the lower border. Each facet with the contiguous one on the adjacent vertebra completes a cavity for the head of a rib. The lower *vertebral notches* are deeper than the upper. Each pair of broad, flat *laminæ* is imbricated, or sloped, over the pair below, like the tiles of a roof. The *spinous process* is long and three-sided, and projects strongly downward, especially in the middle of the series. The *transverse processes* project out-

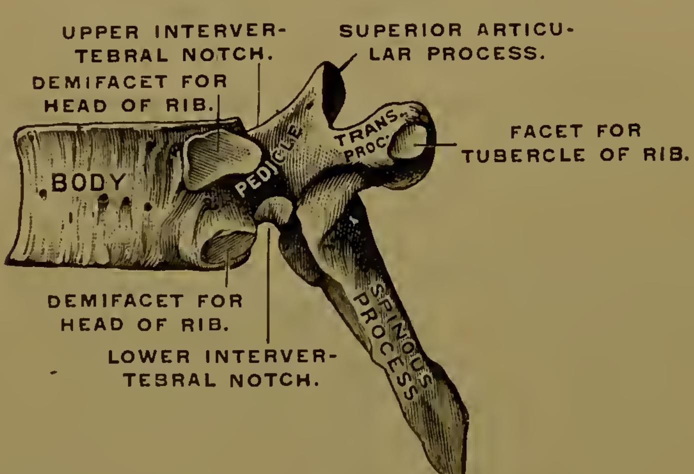


FIG. 138.—Thoracic vertebra, seen from the left side. (Testut.)

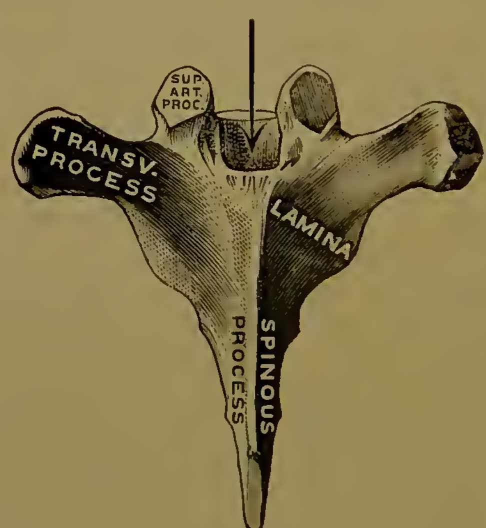


FIG. 139.—Thoracic vertebra, viewed from behind. (Testut.)

ward and slightly backward. The oval facets on the front of their tips are for articulation with the tubercles of the ribs. The rib in situ forms with this process a costo-transverse foramen. Of the two pairs of *articular processes*, the articular surfaces of the upper pair look backward and slightly outward and upward, those of the lower pair forward and slightly inward and downward. The *foramen* is round, and not so large as in the cervical or lumbar region.

Peculiar Thoracic Vertebræ.—These are the first, ninth, tenth, eleventh, and twelfth.

The **first** is a transitional vertebra, resembling the lower cervical vertebræ, especially on its upper surface. The body is elongated transversely, and lipped laterally above. There are entire facets above for the first pair of ribs, and demi-facets below for the second pair. The superior articular processes have largely an upward direction. The spinous process is long, nearly horizontal, and even more prominent than that of the vertebra prominens.

The **ninth** has demi-facets above, but frequently none below. If the lower ones are present, it is a typical vertebra.

The **tenth** articulates with but one pair of ribs. It has no demi-facets below, and the upper facets are usually complete, and mainly on the pedicle.

The **eleventh** has a complete facet on the base of each pedicle, and none on the short transverse processes. The large body is elongated transversely, and the spinous process is short, stout, and horizontal, thus approaching the lumbar type.

The **twelfth** resembles the lumbar still more in its body, spinous and transverse processes. The latter are short, and present external, superior, and inferior tubercles, corresponding to the transverse, mammillary, and accessory processes of the lumbar vertebræ. The inferior articular processes look outward, as in the lumbar. As to facets, it resembles the eleventh.

All the thoracic vertebræ are thus seen to have either entire or demi-facets above, and only the first eight or nine have demi-facets below.

Variety.—The tenth vertebra occasionally has no facets on the transverse processes.

THE LUMBAR GROUP.

The five *lumbar vertebræ* (Fig. 140) are characterized by their large size and the absence of costal articular facets. The *bodies* are elongated transversely, and are slightly deeper in front than behind from the third down. The *laminæ* are strong, short, and deep. The *spinous processes* are thick, horizontal, and broad from above downward. The slender so-called *transverse processes* project outward from the pedicles in serial line with the lower ribs. They are in reality costal processes, and sometimes are developed into lumbar ribs, especially in the first lumbar vertebra. At their bases, dorsally, a small process is seen to project downward—the *accessory tubercle* or rudimentary transverse process. The facets of the *superior articular processes* are slightly concave, and look inward and somewhat backward. Surmounting their posterior border is a tubercle, the *mammillary process*, which corresponds to the superior tubercle of the lower thoracic vertebræ. The facets of the *inferior articular processes* look outward and slightly forward. They are nearer together, and are embraced by the superior processes, but not so closely as to prevent slight lateral and rotatory movements between the vertebræ. The *foramen* is triangular and larger than in the thoracic vertebræ.

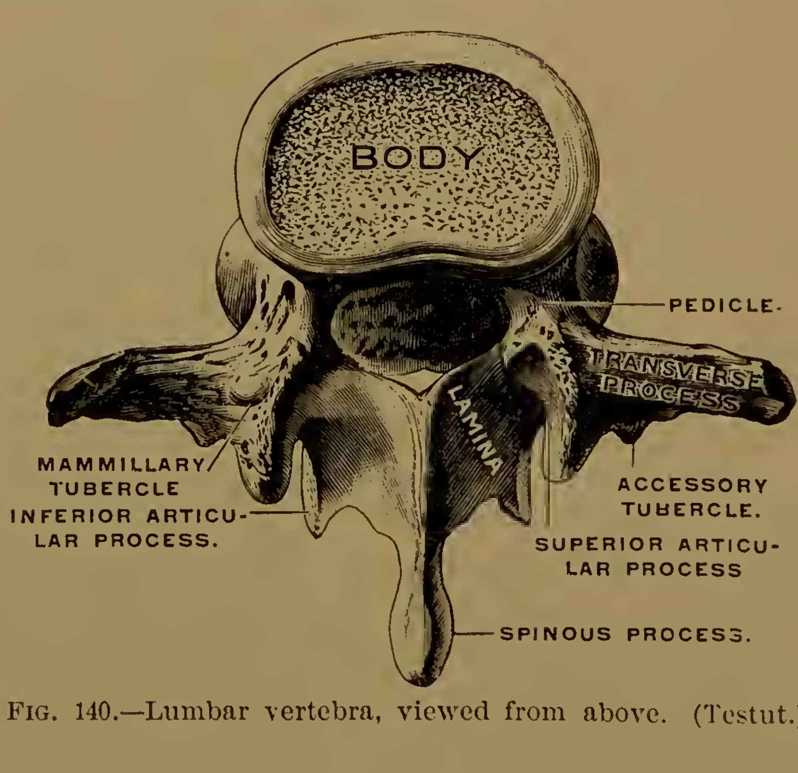


FIG. 140.—Lumbar vertebra, viewed from above. (Testut.)

The **fifth lumbar vertebra** is transitional, approximating the sacral. Its body is large, wedge-shaped, and much deeper in front than behind. To articulate with the first sacral vertebra its inferior articular processes are as wide apart as

the superior. The transverse processes are large, broad, and conical, sometimes articulating with the sacral alæ. The spinous process is short.

Varieties.—In a small percentage (estimated at 5 per cent.) of cases the fifth lumbar vertebra is so separated into two parts through the arch that the dorsal segment consists of laminæ, spinous and inferior articular processes.

Varieties as to the Number of Movable Vertebræ.—The cervical vertebræ are remarkably free from variation in number, not only in man, but in all mammals, with two or three exceptions. Variation in the number of thoracic and lumbar vertebræ may be reciprocal when it depends upon an increase or decrease in the number of pairs of lower ribs, causing an increase in the thoracic and a decrease in the lumbar, or the reverse. Whether the extra vertebra be thoracic or lumbar, the characters of this vertebra are more those of the lumbar type. Or, again, the number of movable vertebræ may be increased or decreased by one, causing an increase or decrease of one in the thoracic or lumbar group. This increase is usually in the lumbar series, the lower one of which may be partly united to the sacrum.

Table showing the Characters of the Typical Vertebræ of Each Group.

	Cervical.	Thoracic.	Lumbar.
Bodies:	Small, transversely elongated. Sloped downward and forward. Lipped laterally. No costal facets.	Heart-shaped. Deeper behind. Nearly equal transversely and anteroposteriorly. Costal facets.	Large, elongated transversely. No costal facets.
Pedicles:	Pass outward and backward. Notches above and below nearly equal.	Pass backward. Inferior notches deeper than superior.	Pass backward and slightly outward. Inferior notches deep.
Laminæ:	Long, slender, flattened.	Broad, deep, imbricated.	Short, deep, and thick.
Spinous processes:	Short, strong, bifid, and nearly horizontal.	Long, projecting downward and overlapping.	Quadrate, horizontal; of medium length.
Transverse processes:	Short, slender, directed outward and forward.	Long, strong. Project outward and backward. Articulate with tubercles of ribs.	Rudimentary, as "accessory process."
Costal process:	Slender, flat, ossified to the vertebra and transverse process.	A separate bone (*i. e.* a rib).	Ossified to vertebra. Flat, thin. Called the "transverse process."
Superior articular processes:	Flat. Directed upward and slightly backward.	Flat. Directed backward and slightly outward.	Slightly concave. Directed inward and slightly backward.
Inferior articular processes:	Flat. Directed downward and slightly forward.	Flat, Directed forward and slightly inward.	Slightly convex. Directed outward and slightly forward.
Spinal foramen:	Large, triangular, wide.	Smaller, circular.	Larger than in the thoracic. Triangular, wide.

The one distinguishing feature of a cervical vertebra is the costo-transverse foramen; of a thoracic vertebra, the articular facet or demi-facet on the body; and of a lumbar, the absence of both of these peculiarities.

THE SACRAL VERTEBRÆ.

These in early life present the elements of five distinct vertebræ, but in the adult they are united into a curved triangular bone, the *os sacrum*, so called from its use in sacrifice (Figs. 141–143). It articulates laterally with the two hip-bones of the pelvic girdle, and thus completes the pelvis behind and above. In the erect position the sacrum lies obliquely, its upper surface or base inclined well forward, and articulating with the fifth lumbar vertebra.

The sacral vertebræ decrease in size from above downward, thus giving the sacrum a triangular shape, with a base, apex, ventral, dorsal, and lateral surfaces. Its separate elements present most, if not all, of the component parts of the movable vertebræ; and the different portions of the sacrum are best understood when studied with reference to these parts.

The *base* of the sacrum, or the upper surface of the first sacral vertebra, resembles that of a lumbar vertebra. The large, transversely oval upper surface

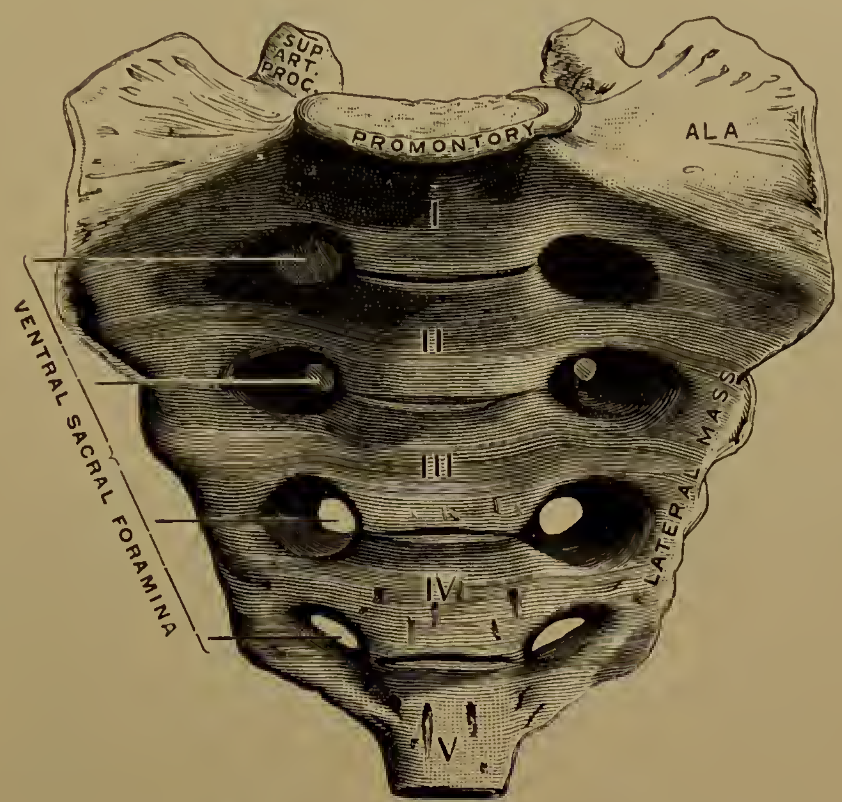


FIG. 141.—The sacrum, ventral view. (Testut.)

of the body extends forward to meet its ventral surface at the *promontory* of the sacrum, which forms the dorsal boundary of the pelvic brim. Its superior *articular processes,* widely separated, look backward and inward like the lumbar, and have well-marked mammillary processes. The *foramen* is triangular. On the sides of the body we see the smooth *alæ,* or wings, on the upper surface of the *lateral masses,* which are formed by the fusion of the transverse and costal

FIG. 142.—The sacrum, dorsal view. (Testut.)

processes on either side. The alæ are continuous with the iliac fossæ on each side.

The *apex* of the sacrum, directed downward and a little forward, is formed by the transversely oval inferior surface of the body of the fifth sacral vertebra.

This articulates with the coccyx by means of an intervertebral disc, which in advanced life often ossifies.

The *ventral surface* looks downward as well as forward. It is concave vertically, less so transversely. In the female it is broader, less curved vertically,

FIG. 143.—The sacrum, its left side. (Albinus.)

and the apex is directed more obliquely backward. The five bodies form the middle of this surface. The upper two are large, the lower three smaller. They are separated by four transverse ridges, the ossified intervertebral discs, which are bounded laterally by the four pairs of *ventral sacral foramina*, the ventral openings of the intervertebral foramina. The ventral foramina transmit the ventral divisions of the first four pairs of sacral nerves, and lead externally into grooves in the lateral masses, which in front consist of fused costal processes.

The *dorsal surface* is convex, rough, and narrower. It presents in the median line the spinous processes of the three or four upper vertebræ, united into one or two ridges by ossification of the connecting ligaments. The fifth spine always, the fourth usually, and all rarely, are wanting. On either side is the *sacral groove,* continuous with the vertebral groove above, and formed by the ankylosed laminæ. The laminæ of the fifth vertebra always, and those of the fourth often, are incomplete, leaving a triangular gap in the lower dorsal wall of the spinal canal. The lower margins of this gap are prolonged down as two tubercles, the *sacral cornua* ("horns"), which represent the inferior articular processes of the

fifth sacral vertebra, and are connected by ligaments with the coccygeal cornua.

On each side of the sacral groove is a series of small prominences, the *articular* and *mammillary processes*, separated from a more external series of larger eminences, the *transverse processes*, by the four *dorsal sacral foramina*. The latter are opposite to, but smaller than the ventral sacral foramina. The four sacral intervertebral grooves on each side pass outward as canals as far as the lateral mass, where they bifurcate and pass forward and backward to the ventral and dorsal foramina.

That part of the bone external to the foramina constitutes the *lateral mass*, whose lateral surfaces are broad and thick above, narrow below. The upper broad part of each lateral surface presents in front an uneven articular surface, called the *auricular surface*, from its ear-like shape, which articulates with the ilium, and behind a rough surface for the attachment of the posterior sacro-iliac ligaments. Below this the narrower rough margin gives attachment to the sacro-sciatic ligaments, and ends in a projection, the *inferior lateral angle*, below which there is a notch, converted into a foramen by ligaments from the coccyx. Through this foramen passes the anterior division of the fifth sacral nerve.

The sacral *spinal canal* curves and narrows with the bone. It is triangular above on transverse section, flattened or semilunar below, and lodges the lower end of the cauda equina and filum terminale and the spinal dura as far as the third vertebra.

Peculiarities and Varieties.—The second and third sacral vertebræ represent the sacrum of mammals, the fourth and fifth the first two caudal vertebræ, while the first represents the sixth lumbar of most quadrupeds. This explains the occasional partial or complete separation, and the transitional and partly lumbar character of the first sacral, which is not uncommon. The large number of sacral vertebræ in man is associated with his upright position. The sacrum sometimes consists of six segments, more rarely of only four. In the former instance the first coccygeal is usually included. The breadth of the sacrum as compared with its length is remarkably great in man as compared with mammals, and especially so in European specimens.

THE COCCYX.

The *coccyx* ("cuckoo's beak") (Fig. 144) consists of four, but sometimes of five and rarely of three, rudimentary vertebræ. These consist of little else than bodies tapering in size from above downward, so as to give the bone a triangular outline. In advanced life they are ankylosed together, and oftentimes with the sacrum; but before then, especially in the female, the first is movable on the succeeding three and on the fifth sacral, with which it is united by fibro-cartilage.

The **first coccygeal vertebra** presents vestiges of a neural arch in two upwardly projecting *cornua* and two laterally projecting *transverse* or *costal processes*. The cornua, representing pedicles and superior articular processes, complete the last intervertebral foramina for the fifth sacral nerves by their connection with the sacral cornua. The transverse processes complete the notches below the lateral sacral angles, which are converted by ligamentous tissue into the fifth anterior sacral foramina.

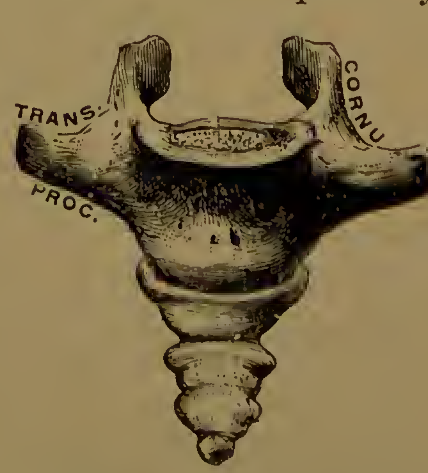


FIG. 144.—The coccyx, ventral surface. (Testut.)

The **second coccygeal vertebra** presents two knobs dorsally and two laterally, vestiges of the neural arch and costal processes, respectively.

Three grooves separate the four bodies. The ventral surface of the coccyx is concave, is closely related to the rectum, and inferiorly gives insertion to the levator ani muscle. To the thin

lateral borders are attached parts of the coccygeus muscle and great sacro-sciatic ligaments, to the tip the external sphincter ani, and to the posterior surface some fibres of the gluteus maximus.

THE SPINE AS A WHOLE.

The *vertebral* or *spinal column* (Fig. 145) is the central axis of the skeleton, and occupies the median line of the trunk dorsally. It supports the head superiorly, the ribs laterally, and through them the weight of the upper extremities. It transmits the weight of these parts to the lower limbs through the hip-bones, with which the sacrum articulates. It also encloses and protects the spinal cord in the bony spinal canal, which is provided with a series of thirty intervertebral foramina on each side for the exit of the spinal nerves. The average length of the spine from the atlas to the tip of the coccyx, following the curves, is twenty-eight inches in the male and twenty-seven inches in the female. About one-quarter of its length is made up of the intervertebral discs.

The *profile view* presents four curves, convex forward in the cervical and lumbar regions, backward in the thoracic and sacral. The thoracic and sacral curves are primary, and occur in the early embryo, accommodating the thoracic and pelvic viscera. They are due to the shape of the bodies, while the secondary cervical and lumbar curves are due largely (if not entirely in the cervical) to the shape of the intervertebral discs. The latter two curves are compensatory to allow the erect position, and are developed after birth. Notice that the upper three curves pass imperceptibly into one another, while the junction of the lumbar and sacral curves makes an angle, the *lumbo-sacral* (or *sacro-vertebral*) *angle*, which forms the overhanging *promontory* of the pelvis. Weight is transmitted by the upper three curves and the first one or two pieces of the sacrum to the hip-bones and lower extremities. In the erect position the chords of these three curves are in the same vertical line, the line of gravity of the head, which passes through the odontoid process, the middle of the bodies of the second and twelfth thoracic, and the ventro-inferior edge of the last lumbar vertebra. The curves add greatly to the elasticity and strength of the column, and thus break shocks and increase its resistance to injury. In addition to these, a slight lateral curve, usually convex to the right, exists in the upper thoracic region, due probably to the greater muscular use of the right side of the body. Pathological exaggerations of all these curves may exist. Such a curvature is called *scoliosis* ("curved") if lateral, *kyphosis* ("humpback") if dorsal, and *lordosis* ("bend") if ventral, the latter being usually compensatory to an ankylosed hip.

The *front view* presents the bodies of the vertebræ becoming broader from the axis to the first thoracic, and from the fourth thoracic to the sacrum; and becoming narrower from the first to the fourth thoracic, and from the first sacral to the tip of the coccyx. Thus, four pyramids are formed; but the total surface area of the bodies steadily increases from above downward to the sacrum. The bodies are widest in the cervical and lumbar regions, where motion is most free.

The *rear view* presents in the middle line the series of spines, nearly horizontal and about opposite the corresponding bodies in the cervical and lumbar regions, thus allowing free motion. The spines of the upper cervical vertebræ are not readily felt in the living body until we reach the seventh, or sometimes the sixth, spine. The upper thoracic spines are easily felt subcutaneously, the lower thoracic and lumbar less so, for they lie in the deep *spinal furrow* bounded by the masses of muscles which occupy the vertebral grooves.

At the sides of the spines are the *vertebral grooves*, bounded externally by the row of transverse processes. The floor of these grooves is formed by

the laminæ, connected by the ligamenta subflava, and by the articular processes with the mammillary processes in the lower part of the spine. The *spinal canal* is large and triangular in the cervical and lumbar regions, smaller and round in the thoracic region, and still smaller and flattened in the sacral region.

The weakest point in the spine is found between the second and third cervical vertebræ, but the union of the thoracic and lumbar curves, or the twelfth thoracic vertebra and those on either side of it, is most liable to injury, for here a fixed part joins the most movable, there is a long leverage on both sides, and the transverse width is less than above or below. Notice that the plane between any two vertebræ is interrupted by the upward and downward projection of the articular processes and other parts connected with the neural arch. Simple dislocation between two vertebræ is, therefore, almost impossible, unless perhaps in the cervical region, where the surfaces of the articular processes are more nearly horizontal. This is borne out in practice, where we find fracture-dislocation the common injury, the processes or neural arch being commonly fractured, if not the body itself.

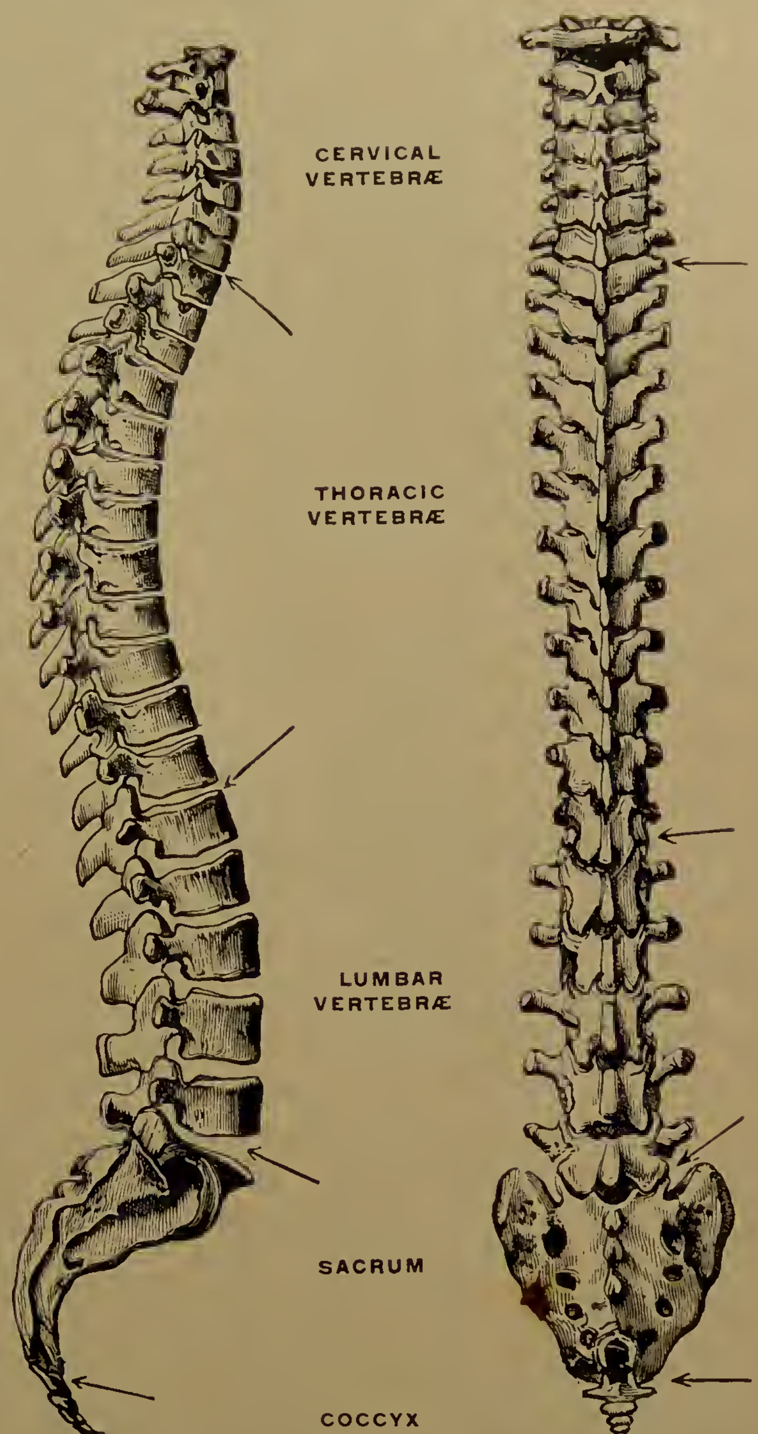


FIG. 145.—The spinal column, right lateral view and dorsal view. (Testut.)

Ossification of the Vertebræ.

The vertebræ are preformed in cartilage (Fig. 146) around the notochord and enclosing the spinal cord. In most cases three primary centres of ossification occur—one on either side in the neural arch, and one in the body. The former unite together in the median line dorsally to form the arch. But sometimes this union fails for a distance, especially in the lumbar and sacral regions,

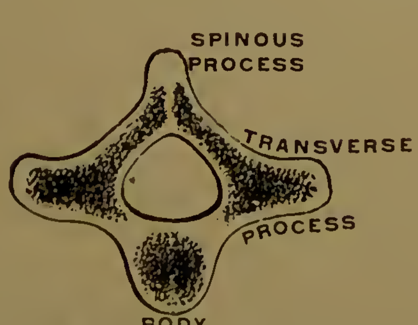


FIG. 146.—Beginning of ossification in the cartilaginous vertebra of a fœtus. (Testut.)

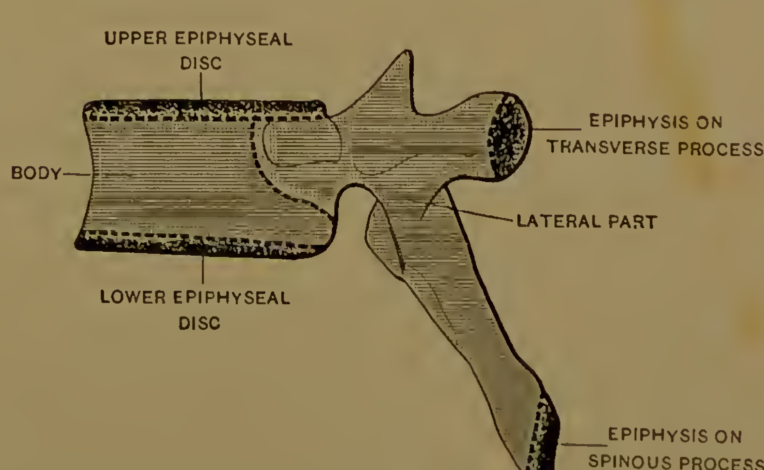


FIG. 147.—Ossification of a thoracic vertebra. (After Testut.)

leaving a gap through which a spina bifida may occur. The part formed by the ossific centres of the neural arch constitutes a varying amount of the lateral and dorsal aspects of the bodies (including the rib facets), separated for a time from

the rest of the body by the cartilaginous neuro-central suture. At birth a vertebra consists of three ossified parts—a body and the two lateral halves of the neural arch—connected by cartilage. Later five epiphyseal centres appear—three of which form tips for the spinous and transverse processes, and two form thin plates on the upper and lower surfaces of the bodies. The mammillary processes of the lumbar vertebræ have each a small centre. The costal processes of the sixth and seventh cervical usually, of the first lumbar sometimes, and occasionally of other cervical vertebræ, are formed from separate centres. These may remain separate and become cervical or lumbar ribs. The various centres are not wholly united until about the twenty-fifth year.

The *atlas* regularly has three centres—one for either half of the neural arch, formed by the lateral masses and the dorsal arch, and the third for the ventral arch. The *axis* (Fig. 148) ossifies much like other vertebræ, but its odontoid process has two laterally placed centres, which unite together, and later with the body of the axis, though the centre of the intervening cartilage persists through

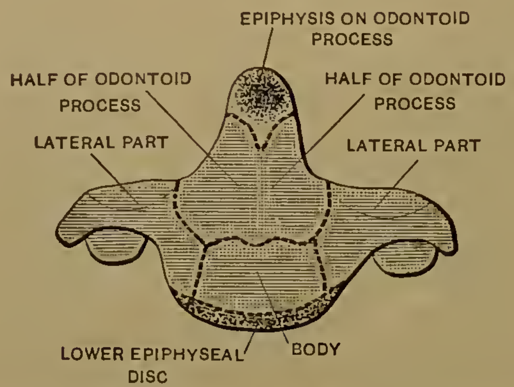


FIG. 148.—Ossification of the axis. (After Testut.)

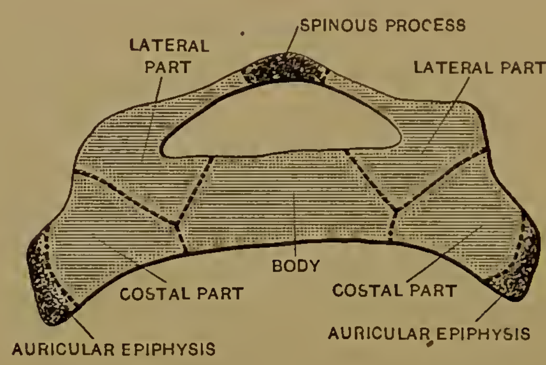


FIG. 149.—Ossification of the sacrum—horizontal section through first piece. (After Testut.)

life. An epiphyseal centre also appears for the apex of the odontoid process. The *sacrum* (Fig. 149) also ossifies essentially like other vertebræ, except that there are separate centres for the costal processes of the upper three vertebræ, and the auricular articular surfaces have two secondary centres each. The intervertebral discs ossify on the surface, but not in the centre, from the eighteenth to the twenty-fifth year, from below upward. The *coccyx* is cartilaginous at birth, and each segment has commonly but one centre. The lower three ankylose before middle life, and these with the first still later, while bony union with the sacrum belongs to advanced age.

Variations.—Two or a single lateral centre may exist in a vertebral body, forming a divided or a half vertebra. In the fifth lumbar vertebra the neural arch has often four centres. The pairs on either side may fail to unite with each other, causing a separation of the laminæ and inferior articular processes from the pedicles, etc.

Serial Morphology of the Vertebræ.—The similarity of construction of the vertebræ in each region of the column is evident from the study of their development and ossification. Centra or bodies are present for all the vertebræ in man, but that of the atlas is dissociated from its neural arch and joined to the body of the axis as the odontoid process. Nothing need be said of the neural arches and spines, except that they are incomplete or wanting in the lower sacral and coccygeal regions. The articular processes are not important morphologically; but the upper three are not homologous with other articular processes, but rather with the lateral parts of the bodies formed by the neural arches. The transverse processes, so called, present more difficulty as well as interest. We find two transversely directed processes—a ventral or costal process and a dorsal or transverse process proper. They present themselves in the simplest form in the thoracic region, where the ventral or costal process is a separate rib, which by articulation with the transverse process encloses an arterial foramen, the costo-transverse. This foramen is seen also in the cervical region, where, however, the

costal processes are ankylosed with the transverse processes and bodies, except when, in the lower cervical vertebræ, they form separate cervical ribs. In the lumbar region the costo-transverse foramen is indicated only by a group of holes at the base of and between the transverse process and the accessory tubercle. The latter represents the tip of the suppressed dorsally situated transverse process, while the transverse process represents a costal process, and in the first lumbar sometimes exists as a separate lumbar rib. In the upper three or true sacral vertebræ the large ventral costal processes and the dorsal transverse processes unite to form the lateral masses which articulate with the hip-bones by means of their costal parts. The mammillary processes (best seen in the lumbar and lower thoracic regions) are rudiments of the much-elongated articular processes in some animals, as the dog, etc.

THE THORAX.

Besides the thoracic vertebræ already described, the skeleton of the thorax ("breast-plate") consists of the sternum, ribs, and costal cartilages.

THE STERNUM.

The *sternum* or *breast-bone* (Fig. 150) is a long, thin, flat bone, situated subcutaneously in the middle of the ventral wall of the thorax. It is connected with the thoracic part of the vertebral axis by the cartilages of the first seven ribs on each side, and, through the attachment of the clavicle, it connects the shoulder-girdle and the rest of the upper extremity with the vertebral axis. It lies obliquely, so that its lower end is farther forward than the upper. The upper end corresponds to the lower border of the second, the lower end to the middle of the ninth, thoracic vertebra.

It consists of three parts, derived from six original segments. The first segment, or upper part, remains separate through life as the *manubrium* ("handle") or pre-sternum, united by fibro-cartilage to the succeeding four segments which form the *gladiolus* ("little sword") or *body* (meso-sternum). The sixth or lower segment, forming the *xiphoid* or *ensiform* ("sword-like") *process* or *appendix* (meta-sternum), remains cartilaginous and distinct to advanced age, when it may ossify in whole or in part, and ankylose with the body. It is usually bent, and often perforated, notched, or bifid. It lies in a plane behind that of the body of the sternum and the cartilages of the seventh ribs. The sternum is longitudinally convex in front, concave behind, and presents transverse ridges where the segments unite. It consists of loose cancellous tissue with a thin shell of compact bone.

The manubrium forms the upper border of the sternum, which is deeply notched in the middle (*interclavicular notch*), and presents at its lateral angles two depressed surfaces looking upward, outward, and backward, where the clavicles articulate. On each side of the manubrium, at the widest part of the sternum, is a rough triangular surface for union with the cartilage of the first rib. Below this the sternum rapidly narrows to the junction of the manubrium and the body, indicated in front by a prominent transverse ridge, which is easily felt through the skin and is an important landmark. The second costal cartilages articulate with surfaces formed of two demi-facets, one on the manubrium and one on the body. The third, fourth, and fifth costal cartilages articulate with the sides of the body at the ends of the transverse ridges between the segments.[1] The sixth and seventh costal cartilages articulate with the sloping and narrow sides of the lower segment of the body, the facet for the seventh cartilage being completed by a demi-facet on the ensiform process. The spaces between the articular facets correspond to the intercostal spaces, and narrow from above downward.

[1] The articulations of the second, third, fourth, fifth, and seventh cartilages with two adjacent sternal segments correspond to the articulations of the heads of their ribs with two adjacent vertebræ.

Muscles Attached.—In front: laterally, the pectoralis major; below the facet for the clavicle, the sterno-cleido-mastoid; to the base of the ensiform process, the rectus abdominis; to the sides and tip of the ensiform process, the aponeurosis of the oblique and transverse abdominal muscles. Behind: near the superior

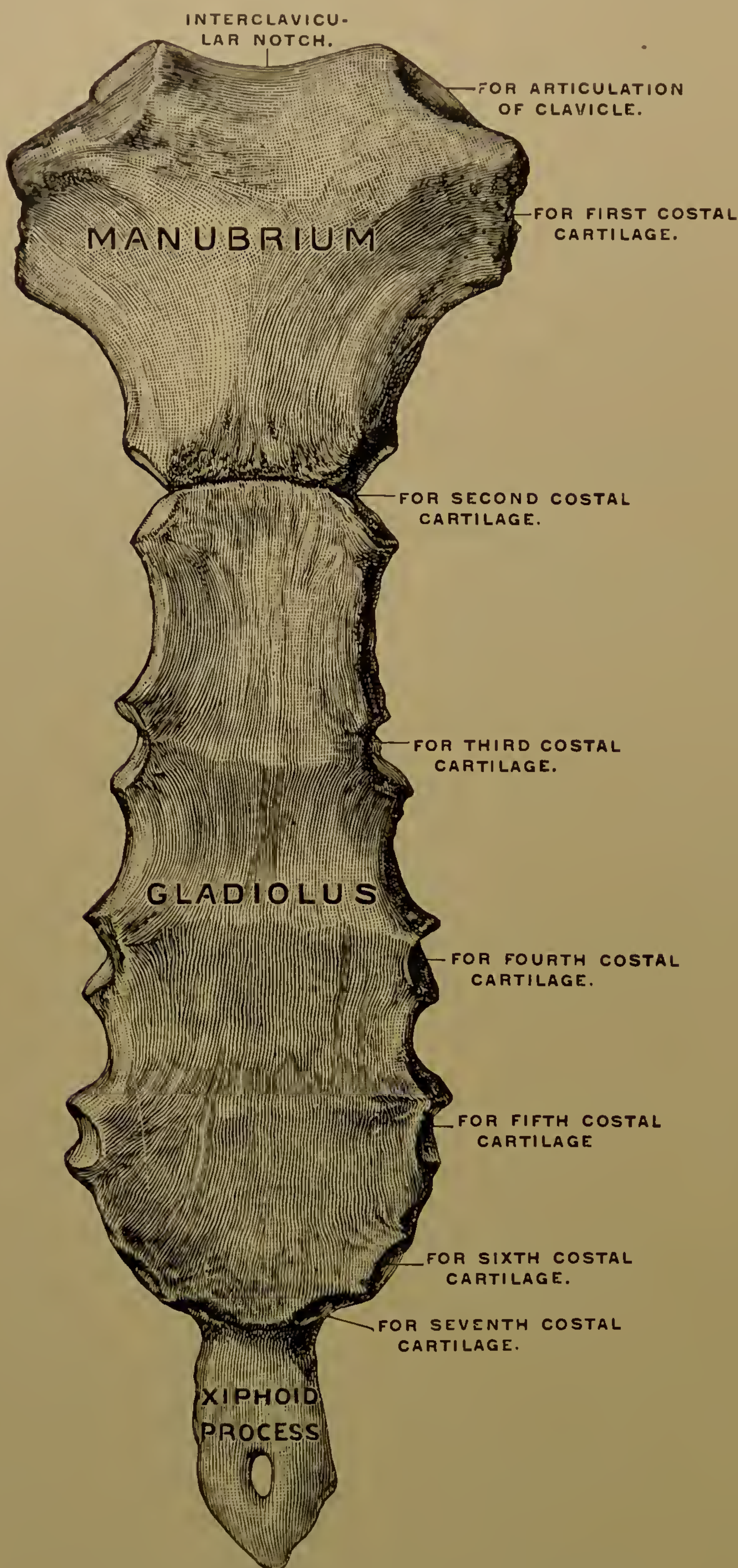


Fig. 150.—The sternum, ventral aspect. (Spalteholz.)

angles, the sterno-hyoid and sterno-thyroid; laterally, in the lower four segments, the triangularis sterni; to the ensiform process, the diaphragm. On the sides: between the facets, the internal intercostals.

The sternum articulates with seven, and occasionally eight, costal cartilages and the clavicle on each side.

The sternum is subcutaneous at the bottom of the *sternal groove*, which is due

to the lateral prominences of the pectoral muscles, and is limited above by the interclavicular notch and below by the infrasternal depression, due to the prominence of the seventh costal cartilages above the level of the ensiform process. The proportionate length of the body of the sternum is greater in the male than in the female. Its average length is six inches in the adult male, somewhat less in the female.

Development.—The sternum is formed by the fusion of the ventral cartilaginous ends of the upper ribs into two lateral bars, which later fuse together mesially, except in rare cases where a cleft sternum exists.

Ossification is irregular, but usually the first two segments present a single primary centre, while two laterally placed centres commonly occur in the succeeding segments. By the failure of the latter to unite across the median line a median foramen or a vertical fissure may be left.

THE RIBS.

The *ribs* (costæ) extend in twelve pairs from the thoracic vertebræ in an outward and forward curve toward the median line in front. They form the lateral walls of the thoracic cage, and are prolonged in front by the costal cartilages. As the upper seven pairs of the latter pass to the sternum, the corresponding seven pairs of ribs are called *true* or *sternal ribs,* while the lower five pairs are called *false* or *asternal ribs.* Of the latter, the lower two pairs are called *floating ribs,* as their forward ends are free, while those of the three pairs above them are connected together. The length of the ribs increases from the first to the eighth, and thence it decreases to the twelfth. The greatest breadth is found at the sternal end. The ribs are highly elastic, owing to their slenderness and curvature.

The general characters of typical ribs are best marked in ribs like the seventh, near the centre of the series. A *typical rib* (Fig. 151) consists of an enlarged

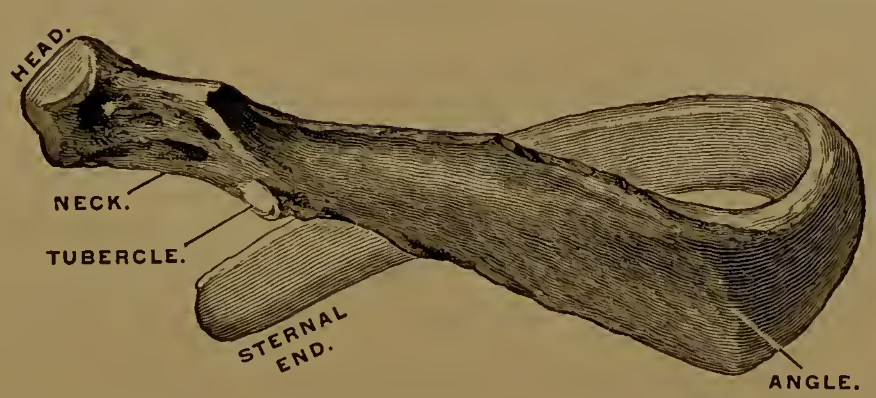


FIG. 151.—The eighth rib of the right side viewed from behind. (Spalteholz.)

vertebral end, or head, joined by a constricted neck to a shaft, presenting a tubercle, an angle, and a sternal end. The *head* shows two articular facets, separated by a slight horizontal ridge, to which the interarticular ligament from the intervertebral disc is attached. The facets articulate with the two demi-facets on the sides of the bodies of two contiguous vertebræ. The lower facet is the primary and larger one, and articulates with the vertebra which corresponds in number to the rib, and it is the only facet where there is but one. The *neck* is the part between the head and the tubercle. It is rough behind and along the upper and lower borders for the costo-transverse ligaments, and forms the ventral boundary of the costo-transverse foramen. The *tubercle* is divided by an oblique groove into an inner and lower smooth portion for articulation with the front of the tip of the transverse process of the vertebra of the same number as the rib, and an outer and upper rough part for the posterior costo-transverse ligament. The *body,* or *shaft,* beginning with the tubercle, extends to the cupped *sternal end,* which receives the costal cartilage. It is laterally compressed, so as to present inner and outer surfaces and upper and lower borders. On the inner aspect of the inferior border is the *subcostal groove,* which lodges the intercostal vessels and

nerve. It is best marked near the angle, and is limited above by a ridge which is continuous with the inferior border of the neck and gives attachment to the internal intercostal muscle. The inferior border, which begins near the angle, affords attachment to the external intercostal muscle; the superior border to both intercostal muscles; the convex external surface to various muscles.

The shaft is curved on a vertical axis, or rather two axes. The dorsal and sharper curve extends from the head outward to the *angle*, where the rib takes a sudden bend, in front of which the curve is more gradual. The curvature of the ribs decreases from the first, the most curved, to the twelfth, the least curved.

FIG. 152.—The sixth rib of the right side viewed from the middle line of the body. (Spalteholz.)

The back of the angle is rough, for the attachment of the iliocostalis muscle and its upward continuation. At the angle the ribs from the third to the twelfth are also bent on a horizontal axis, so that if they be rested on their lower borders the head end of the ribs curves upward from the angles. This curve increases from the third to the seventh, and thence decreases to the twelfth. The head end of the first and twelfth bend slightly downward; that of the second is in line with the shaft. This curve is sometimes spoken of as a twisting of the rib on itself. It increases the obliquity of the ribs as far as the seventh or eighth.

Peculiar Ribs.—The *first rib* (Fig. 153) is the least oblique, and is so placed that its surfaces present upward and downward. If laid on its lower surface, the head end does not bend up, but slightly down. The small head has but a single facet, the neck is long and narrow, and the tubercle and angle coincide. On the broad superior surface near the centre of the internal border is a rough mark, the *scalene tubercle*, the origin of the scalenus anterior muscle. It separates a groove in front for the subclavian vein from one behind for the subclavian artery. Behind the latter groove are attached the first digitation of the serratus magnus externally and the scalenus medius internally. The subcostal groove is wanting. The *second rib* (Fig. 153) has no upward curve of the head end, but it lies almost perfectly flat. The upper surface looks obliquely outward, and has a prominent roughness for the serratus magnus. The angle is but slightly marked. The *tenth rib* has usually a single facet on the head, sometimes two facets. The *eleventh rib* has but one facet, no neck or tubercle, a slight angle, and a shallow

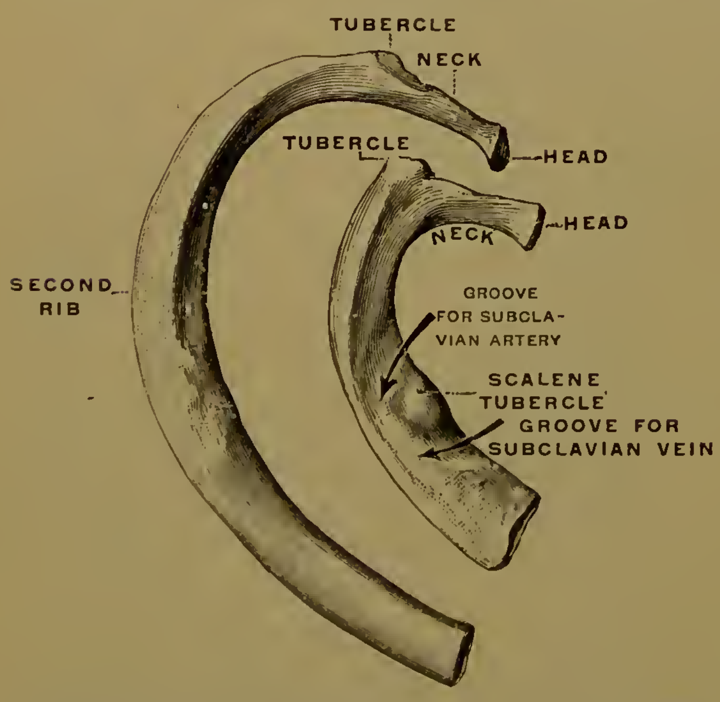


FIG. 153.—The first and second ribs of the right side, viewed from above. (Testut.)

subcostal groove. The *twelfth rib* resembles the eleventh, but has no angle and no subcostal groove. It is shorter, and may be rudimentary, measuring less than 1 inch in length—an important point in lumbar incisions. It either lies flat on its lower border, or its head end may bend slightly downward. Its outer surface may incline somewhat downward.

Variations.—Thirteen ribs may occur on one or both sides, from the presence of a cervical or lumbar rib. The additional ribs are developed from the costal processes, and are usually short and imperfect, especially the lumbar. Very rarely a thirteenth thoracic rib occurs. The tenth rib may have no articular facet on the tubercle.

Ossification.—The ribs are preformed in cartilage, and have a single primary centre near the angle. Much later two epiphyseal centres appear—one for the head and one for the tubercle—which become united to the rest of the bone by the twenty-fifth year.

THE COSTAL CARTILAGES.

The *costal cartilages* are bars of hyaline cartilage prolonging the ribs toward the sternum. In direction the first passes slightly downward as well as inward, the second is horizontal, and the rest, down to the eleventh, are directed successively more and more upward in passing inward. Their breadth diminishes from the first to the twelfth, and is greater at the costal than at the sternal end of each cartilage. Their length increases to the seventh, and thence becomes gradually less. In shape they resemble the sternal ends of the ribs. The inner extremities of the upper seven are connected with the sternum, the first being fused with it, the others articulated. The cartilages of the upper three false ribs are attached at their upturned, narrow, inner ends to the lower border of the cartilages next above. The cartilages of the floating ribs are short, and have a pointed free end. The borders and surfaces afford attachment to muscles—the inner surface to the triangularis sterni, from the second to the sixth, and to the diaphragm and transversalis in the lower six; the borders to the internal intercostals. The costal cartilages represent unossified epiphyses of the rib-shafts. The costal cartilages are covered by a thick perichondrium, beneath which superficial ossification may occur in advanced life. This change occurs quite regularly in the first cartilage, but in the others less commonly, at a later period, more particularly in front, and more often in the male than in the female.

THE THORAX AS A WHOLE.

The bony thorax (Figs. 154, 155) forms an irregular, truncated cone, compressed from before backward. It is longer behind than in front, so that its upper small reniform aperture, or *inlet*, looks slightly forward as well as upward, and the plane of the lower opening, or *base*, also looks forward and downward. The margin of the irregular base is formed by the two curved lines of the edges of the lower six pairs of ribs and cartilages, converging to the xiphi-sternal junction, and bounding the *subcostal angle*, in the centre of which projects the ensiform process. The *dorsal wall*, formed by the thoracic vertebræ and the ribs as far as the angles, is convex from above downward. The backward curve of the ribs forms a broad furrow externally, the *vertebral groove*, on each side, between the angles of the ribs and the vertebral spines, which lodges the erector-spinæ muscle group. This backward position of the angles of the ribs, about on a level with the thoracic spines, causes the flatness of the back which allows the supine position characteristic of man. The *ventral wall*, formed by the sternum and costal cartilages, is inclined downward and forward at an angle of 20° or 25° with the vertical plane, and is only slightly convex. The *sides*, formed by the ribs, from the angles to the cartilages are convex from above downward; much more so from before backward. From about the ninth rib down they slant

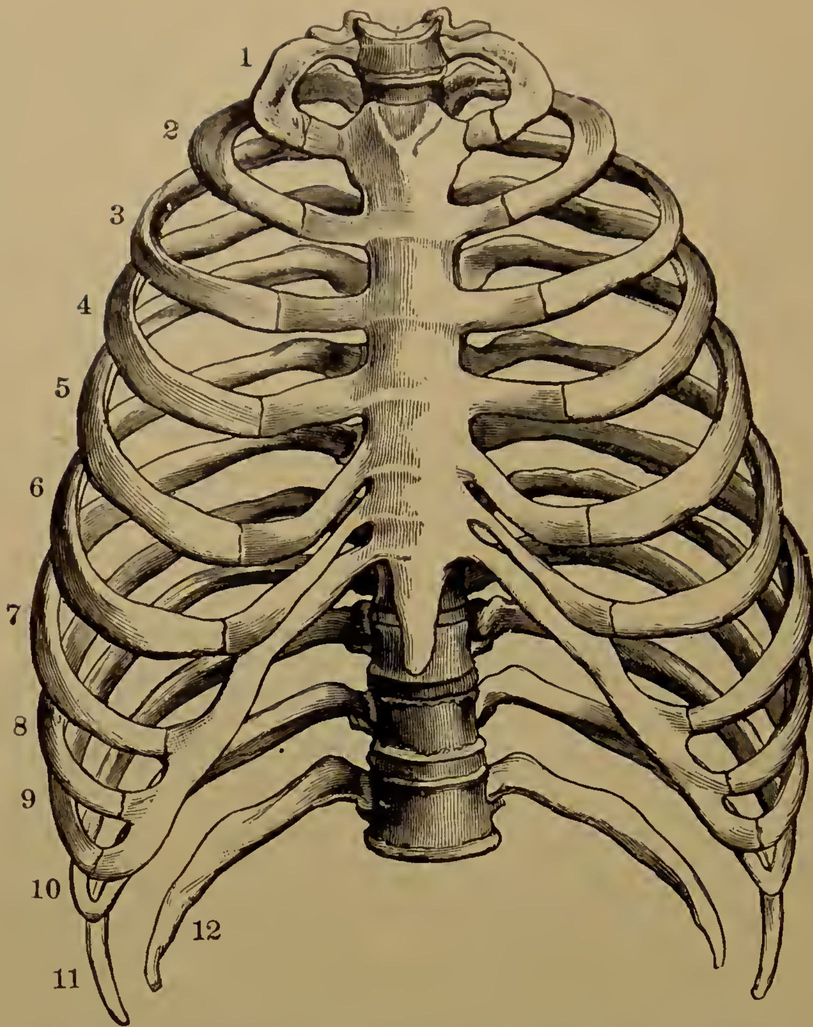


FIG. 154.—The skeleton of the thorax, front view. (Testut.)

inward. The *interior* corresponds in shape to the exterior, except for the median projection of the vertebral bodies, which makes the median antero-posterior diam-

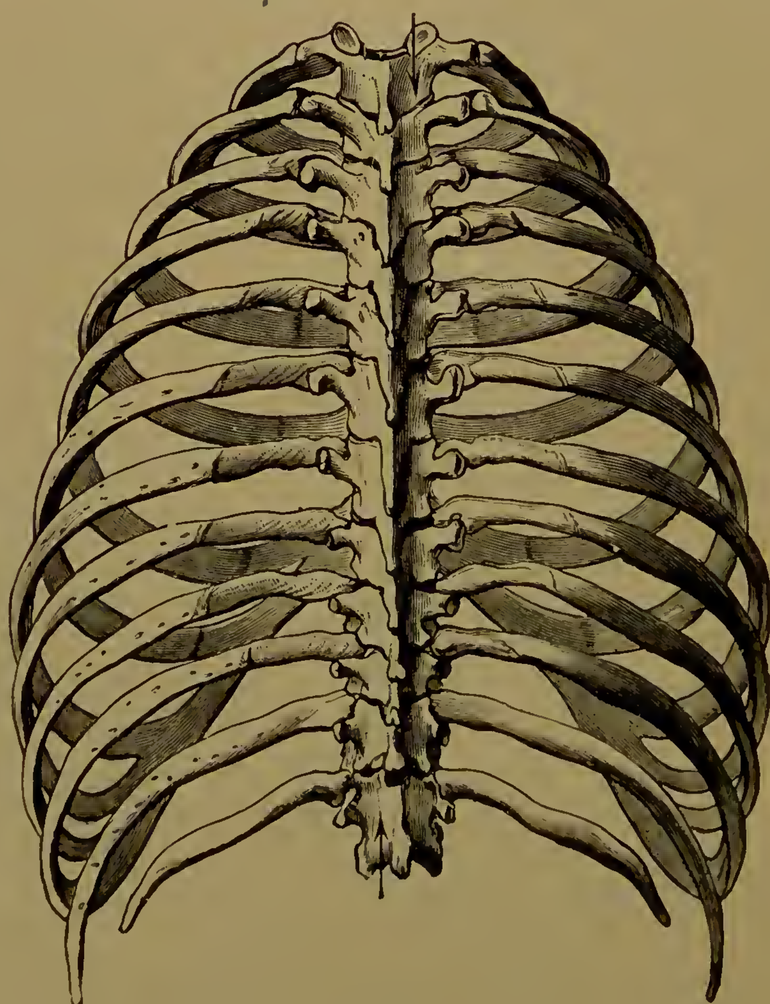


FIG. 155.—The skeleton of the thorax, dorsal view. (Testut.)

eter less than that on either side, and only little more than one-half of the corresponding external diameter. The lateral grooves formed by the forward projec-

tion of the vertebral bodies and the backward curvature of the ribs lodge about as much of the lungs as lies in front of a transverse plane tangent to the arc of the thoracic curve. This circumstance, together with the wide transverse diameter characteristic of man, throws the weight farther back, and makes easier the balance around the spinal axis in the erect position.

The ribs are more and more oblique from above downward as far as the seventh or lower—a fact due in part to the increasing downward curvature from the head to the angle, and in part to the increasingly lower position of the transverse processes of the lower thoracic vertebræ. This increasing obliquity of the ribs makes the eleven intercostal spaces wider at the sides than behind. These spaces contract again somewhat in front from the third to the eighth. They are widest in the upper three spaces, and wider in inspiration than in expiration. It should be remembered that the circumference of the right half of the thorax is usually about half an inch larger than that of the left. Note that the lower palpable end of the gladiolus is on a level with the lowest part of the fifth rib. At birth the thorax may measure even more from before backward than transversely, as is the case with quadrupeds. This is due to the absence of the angles and to the less curvature of the ribs at this period. In the female the thorax is relatively shorter, and deeper from before backward, although the latter diameter is actually less than in the male.

The thorax is admirably adapted for the combined purpose of protecting its contained viscera and allowing the movements necessary in respiration. This is provided for by the presence of a number of separate bones, the ribs, which serve for protection, and each of which has a moderate amount of motion.

THE BONES OF THE UPPER LIMB.

The skeleton of the upper limb comprises the clavicle and scapula, forming the pectoral arch or shoulder-girdle, the humerus in the arm, the radius and ulna in the forearm, and the carpal, metacarpal, and phalangeal bones in the hand.

THE CLAVICLE.

The *clavicle* ("little key") or *collar-bone* (Figs. 156, 158) passes outward and backward from the top of the sternum to the acromion process of the scapula, and forms the connecting link between the trunk and the arm, affording a fulcrum in the movements of the latter. It is curved like an italic *f*. Its inner

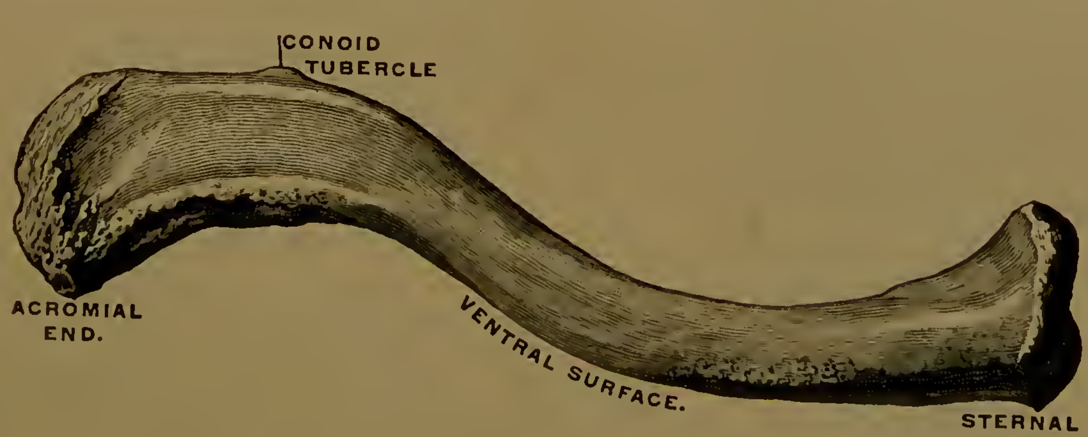


FIG. 156.—The right clavicle, upper surface. (Spalteholz.)

two-thirds, prismatic or cylindrical, is convex forward like the thorax below it; its outer third, flattened from above downward, is concave forward, corresponding to the hollow between the thorax and the shoulder.

The *superior surface* is flat and broad in its outer third, where it is overlapped by the attachment of the trapezius behind and the deltoid in front, with a subcutaneous area between. In the inner two-thirds it is rounded and subcutaneous

externally, and marked by the attachment of the sterno-cleido-mastoid internally. The *ventral surface* in its outer third is merely a rough border for the origin of the deltoid, near the inner limit of which is the *deltoid tubercle,* when present. In its inner two-thirds it is broader, and rough for the origin of the pectoralis major muscle. The *inferior surface* presents the rough *trapezoid line,* running inward and backward from near the front of the outer end to the *conoid tubercle,*

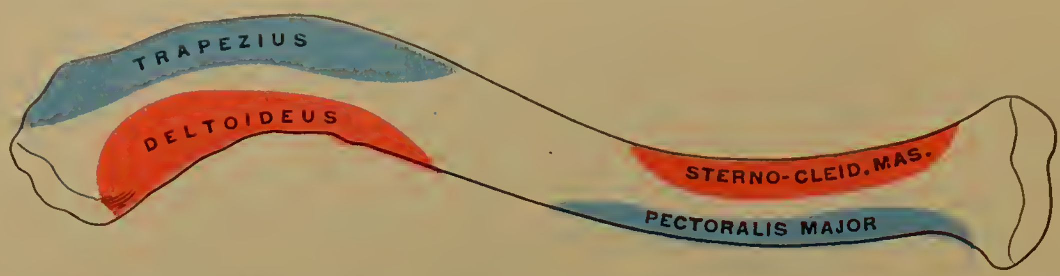


FIG. 157.—Areas of muscular attachment, upper surface of right clavicle.

near the dorsal border at the junction of the outer fourth and the inner three-fourths. These respectively give attachment to the trapezoid and conoid portions of the coraco-clavicular ligament. Internal to the conoid tubercle is a shallow groove for the insertion of the subclavius muscle. Near the sternal end is a

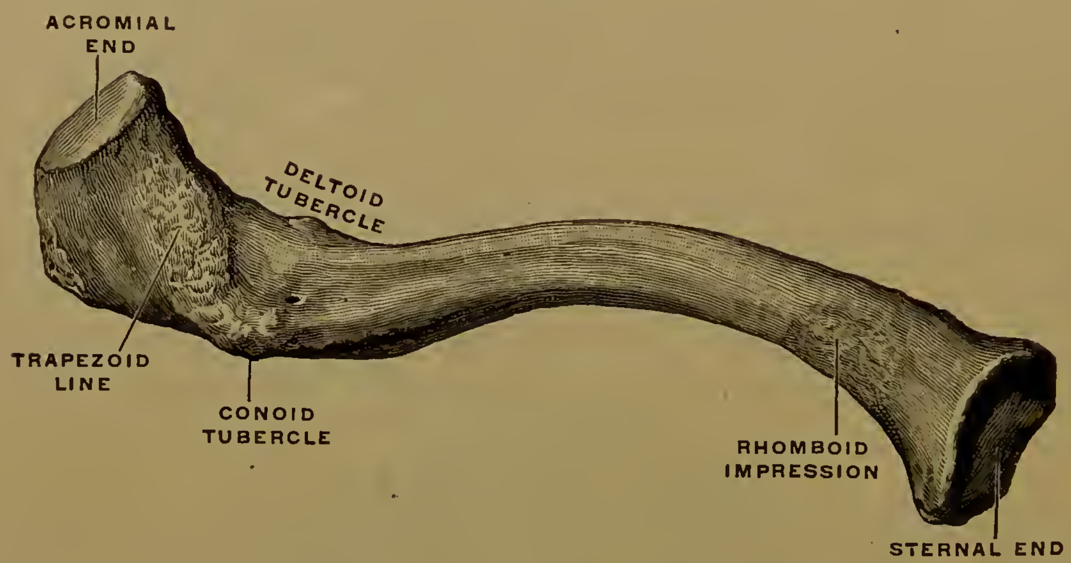


FIG. 158.—The right clavicle, under surface. (Spalteholz.)

rough impression for the rhomboid ligament which binds the clavicle to the first rib. Internal to this impression is a facet where the clavicle plays on the first costal cartilage. This facet is continuous with the sternal facet, and close beside it the sterno-hyoid muscle is attached. The *dorsal surface,* like the ventral, is

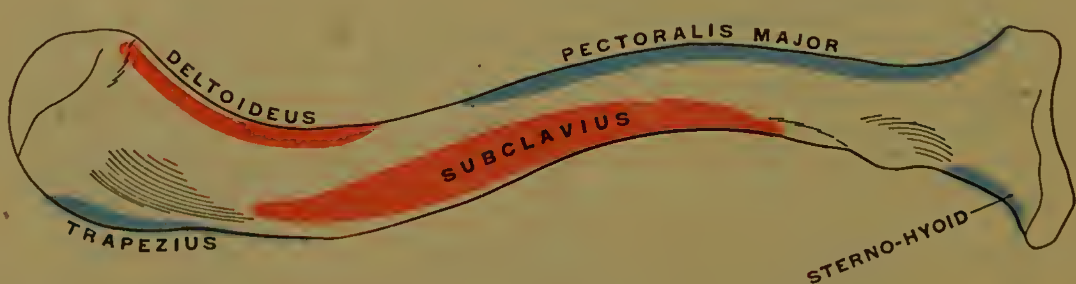


FIG. 159.—Areas of muscular attachment, lower surface of right clavicle.

merely a rough border in its outer third, where the trapezius muscle is inserted. In its inner two-thirds it is broader and smooth, and arches over the subclavian vessels and the brachial plexus. The nutrient foramen is usually seen passing outward near the middle of this surface, but sometimes it is on the inferior surface. Part of the clavicular attachment of the sterno-cleido-mastoid is found at

the sternal end of this surface. The border[1] separating the dorsal and inferior surfaces passes from the conoid tubercle to the rhomboid impression.

The *sternal end* is expanded into a triangular or oval articular surface, which plays upon the interarticular fibro-cartilage between it and the sternal facet. Its rough borders give attachment to the sterno-clavicular and interclavicular ligaments. The *acromial end* presents an oval articular surface, elongated from before backward, and bevelled inferiorly, which articulates with the acromion process of the scapula. Its upper surface is on a little higher level than that of the acromion.

The clavicle has no medullary cavity, but is composed of cancellous tissue with a shell of compact bone. It is more or less subcutaneous throughout, but especially so in the intermuscular interval near its centre. Fracture is very common, especially at the junction of its two curvatures (inner two-thirds and outer one-third). The clavicle is longer, stronger, rougher, and more curved in the male than in the female, and on the right side than on the left. In the male it also inclines slightly upward as it passes outward.

Ossification.—The clavicle is the first bone to ossify. It begins in membrane, but quickly extends into the underlying cartilage of the precoracoid bar. An epiphysis, appearing at the sternal end between the eighteenth and twentieth years, is united to the shaft about the twenty-fifth year.

THE SCAPULA.

The *scapula* (Figs. 160, 162) is a large, flat, triangular bone, forming the dorsal part of the shoulder-girdle. It rests upon the upper and back part of the thorax, and from it is suspended the humerus. Its surfaces are ventral and dorsal; its borders superior, internal, and external; and from its external angle or head, which bears an articular surface, projects the coracoid process. The spine, prolonged into the acromion process, projects from its dorsal surface.

The *ventral surface*, or *venter*, presents the *subscapular fossa*, a deep concavity most marked above. From the inner two-thirds of this fossa, which is marked by three or four oblique ridges, the subscapularis muscle arises. This fossa is separated from the internal border by a linear area, which, with its two triangular expansions opposite the upper and lower angles, gives insertion to the serratus magnus muscle. Externally, the fossa is limited by a smooth, prominent ridge descending from the head of the bone. From the narrow groove between this ridge and the external border arise some fibres of the subscapularis. The convex *dorsal surface* or *dorsum* is unequally divided by a prominent ridge, the *spine*, into an upper smaller *supraspinous fossa*, and

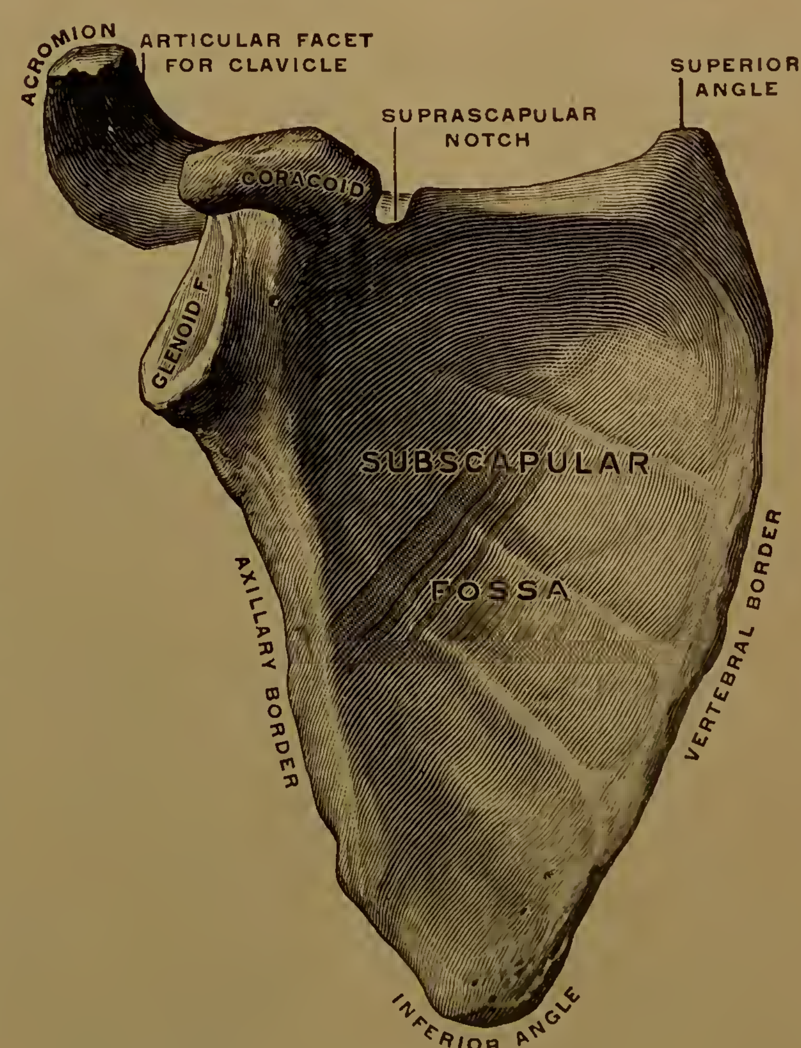


FIG. 160.—The right scapula, ventral view. (Spalteholz.)

[1] No other border needs description. The clavicle is often described as having three surfaces and three borders in its inner two-thirds, and two in its outer third. In this less common or less accurately described condition the ventral border is expanded in its centre for the attachment of the pectoralis major muscle.

a lower larger *infraspinous fossa*, giving origin to the supraspinatus and infraspinatus muscles, respectively. The two fossæ communicate around the outer

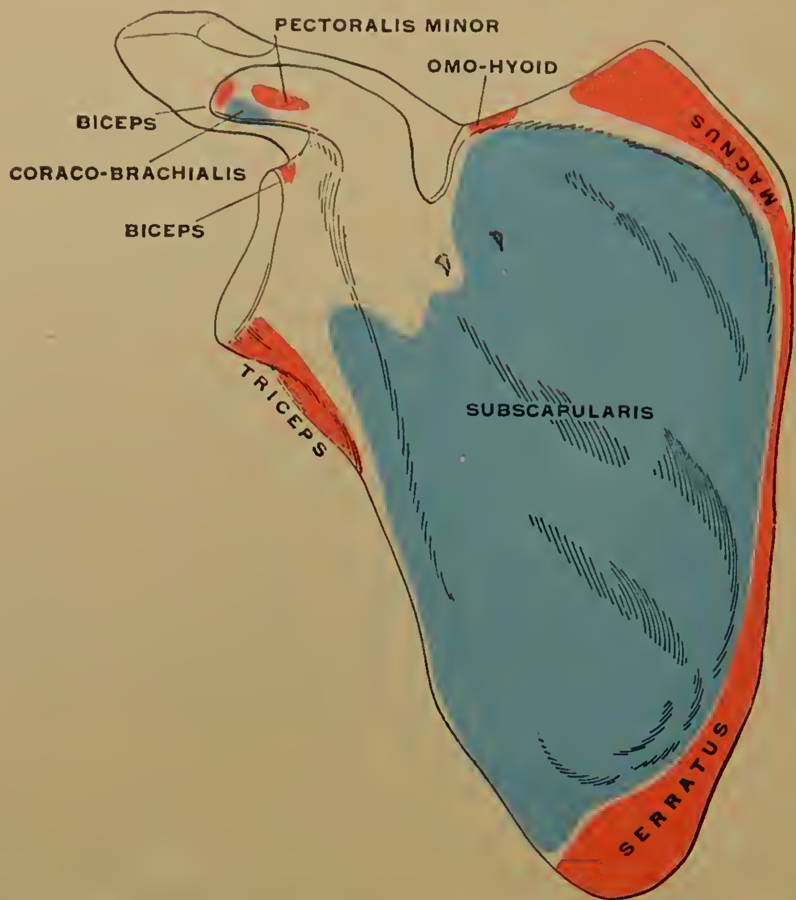


FIG. 161.—Areas of muscular attachment, ventral surface of right scapula.

border of the spine by means of the *great scapular notch*, which corresponds to the neck of the bone, and transmits the suprascapular nerve and vessels from one fossa

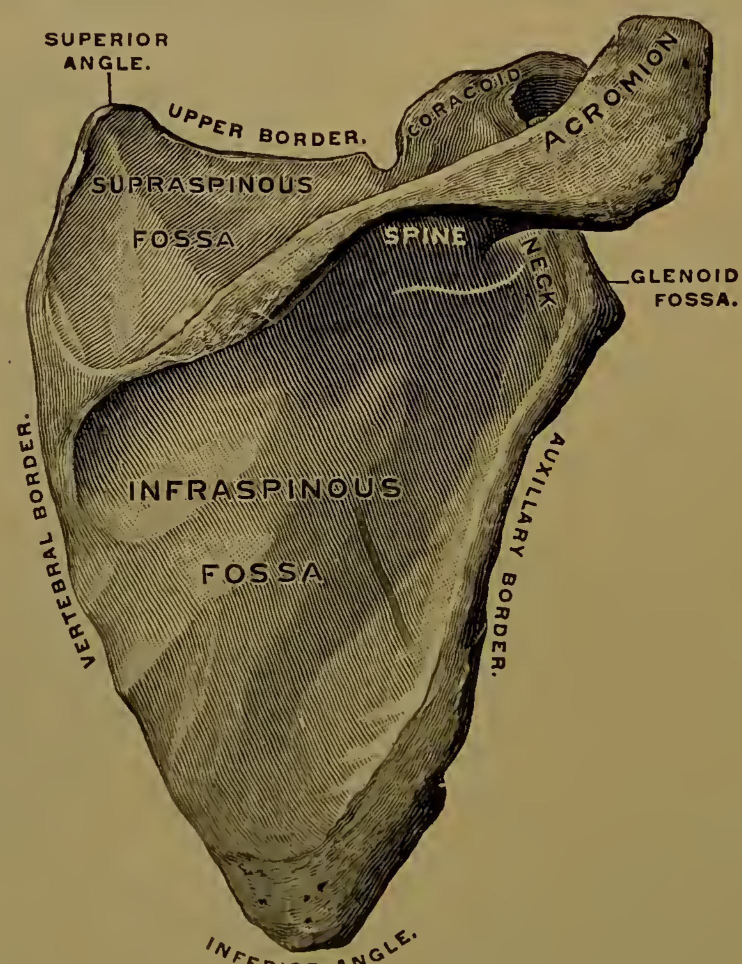


FIG. 162.—The right scapula, dorsal view. (Spalteholz.)

to the other. An oblique ridge running from below the glenoid fossa to the vertebral border just above the inferior angle separates the infraspinous fossa from a

narrow space between this ridge and the external border. This space gives origin to the teres minor muscle above and the teres major, on the broader portion, below.

The massive triangular *spine* of the scapula commences about the upper fourth of the vertebral border as a smooth, expanded, triangular surface, covered by a bursa over which the lower part of the trapezius glides to be inserted into a tubercle beyond. From this point, projecting backward and upward, and becoming more and more elevated, it extends outward and a little upward to the middle of the neck of the scapula. Thence it is continued forward and outward as the flat, quadrate *acromion* ("summit of the shoulder") *process*, overhanging the shoulder-joint. The upper and lower smooth, concave surfaces of the spine form part of the supra- and infraspinous fossæ respectively. Of the two unattached borders, the short, smooth, and concave *external border* arises at the neck of the scapula, where it bounds the great scapular notch, and is continuous with the under surface of the acromion. The more prominent subcutaneous *dorsal border*, or *crest*, is rough, broad, and serpentine. Commencing at the above-mentioned triangular surface, it passes outward to become continuous with the rough,

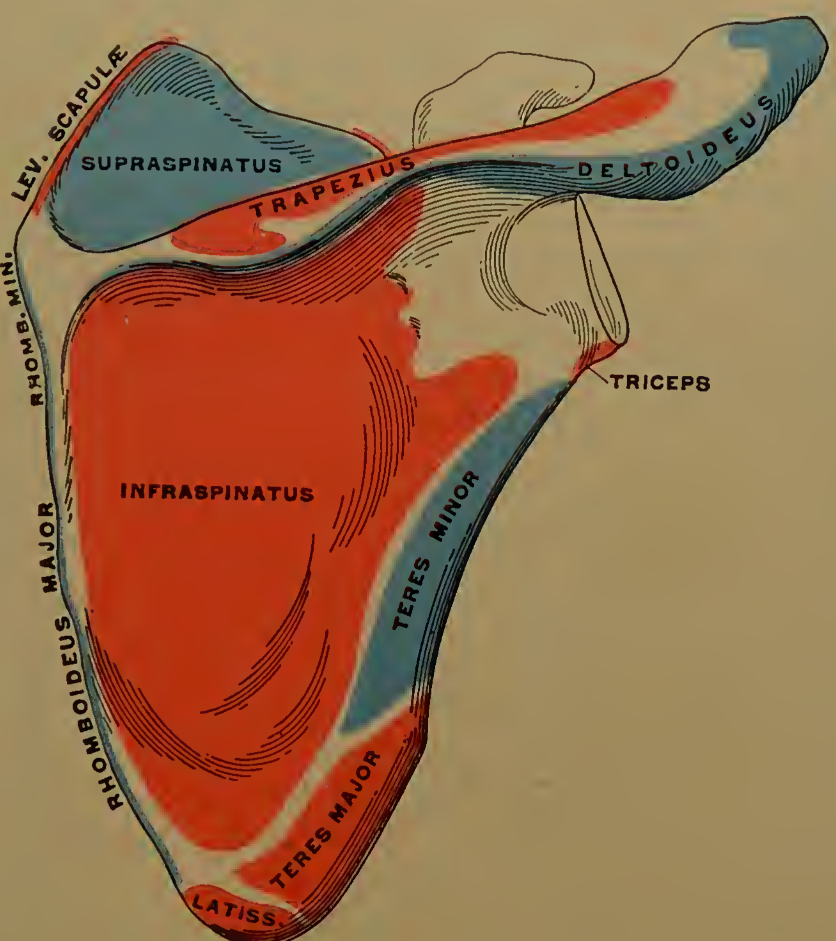


FIG. 163.—Areas of muscular attachment, dorsal surface of right scapula.

subcutaneous *upper* surface of the acromion. The upper lip of the crest is continuous with the *inner* border of the acromion, and to them is attached the trapezius muscle as far as the oval facet for the outer end of the clavicle, on the inner border of the acromion near its tip. The lower lip of the crest is continuous with the outer border of the acromion, with which it forms an angle, the *acromial angle*, and from them the deltoid takes origin. From this angle the measurements are taken to determine the length of the humerus. To the apex of the acromion is attached the coraco-acromial ligament, and its under surface, continuous with the upper surface and the outer border of the spine, is smooth and covered by a bursa.

The *internal* or *vertebral border* (or base) is long and irregularly convex. Opposite the commencement of the spine it bends more sharply, and here is inserted the rhomboideus minor muscle, while below this area the rhomboideus major is attached by a fibrous arch, and above it the levator scapulæ is inserted. The *superior border*, short, sharp, and concave, extends from the superior angle to the base of the coracoid process, where it presents the *suprascapular notch*,

converted into a foramen by the transverse ligament (sometimes by a spicula of bone). The foramen transmits the suprascapular nerve, and from the ligament and the adjacent border the omo-hyoid muscle arises. The *external* or *axillary border* is quite thin, and just below the glenoid fossa presents a rough impression, from which the long head of the triceps arises. A little below this is a groove for the dorsal artery of the scapula.

The long, rounded, thick *inferior angle* is often called *the* angle of the scapula. To its dorsal aspect some fibres of the latissimus dorsi muscle are frequently attached. The *external angle* presents the *head*, supported on a slightly constricted *neck*, and bearing the articular *glenoid cavity* for the humerus. The glenoid cavity is shallow and pear-shaped, with the narrow end above, and indented on its ventral lip above its centre. It looks outward, upward, and forward. To its rim is attached the glenoid ligament, which deepens the shallow cavity, and outside of this the capsular ligament is attached. The long head of the biceps arises from its upper extremity. From the upper border of the neck the thick, strong *coracoid* ("like a crow's beak") *process* rises nearly vertically for a short distance, and then bends sharply forward and outward in front of, and more or less parallel with, the acromion. From the tip of the process arise the short head of the biceps, the coraco-brachialis, and the costo-coracoid ligament. To its inner border the pectoralis minor muscle is attached, and to its outer border the coraco-acromial ligament. Its superior surface is rough, and affords attachment, near the base, to the coraco-clavicular ligament (conoid and trapezoid portions).

When the arm hangs by the side the scapula rests upon the ribs, from the second to the seventh inclusive, and the inner end of its spine corresponds to the third thoracic spine[1] or the space below it. The distance between the spines of the vertebræ and the vertebral border averages two inches. The tip of the coracoid process is palpable below the clavicle and internal to the humeral head, except in fat subjects. The dorsal border of the spine, the upper surface of the acromion, and the lower part of the vertebral border are also subcutaneous.

Ossification occurs in cartilage from two primary and five secondary centres. From the primary centres the body and coracoid process are formed. The coracoid joins the body about the fifteenth year, when two centres appear in the acromion, which soon unite together and join the spine about the twentieth year, though sometimes this union fails, and the acromion is movable on the spine. Two other centres appear in the cartilage along the vertebral border, and another between the glenoid cavity and the coracoid process.

Morphology.—The coracoid process represents the coracoid bone, or ventral bar of the shoulder-girdle of other animals. Its ventral end has degenerated into the costo-coracoid ligament. The glenoid fossa is the meeting-point of the coracoid and the dorsal segment or scapula. The precoracoid bar of the shoulder-girdle is replaced by the clavicle in man.

THE HUMERUS.

The *humerus* (Figs. 164, 166) constitutes the skeleton of the arm, and extends downward and slightly inward from the shoulder to the elbow. It presents, like all long bones of the limbs, an upper and a lower extremity and a shaft.

The large *upper extremity* includes the head, neck, and two tuberosities. The large cartilage-clad *head* represents about one-third of a sphere, whose vertical diameter is slightly longer than the transverse. It is directed inward, upward, and backward, at an angle of 130° with the axis of the shaft, to articulate with the glenoid cavity of the scapula. The *anatomical neck* is the slight constriction below and external to the head, to which the capsular ligament is attached. Superiorly, it is a mere groove between the head and the tuberosities. The latter are separated from one another by the commencement of the bicipital groove. The *great tuberosity*, the higher and more dorsally placed, is continued up from

[1] And also to the fissure between the upper and lower lobes of the lung.

FIG. 164.—The right humerus, front view. (Testut.)

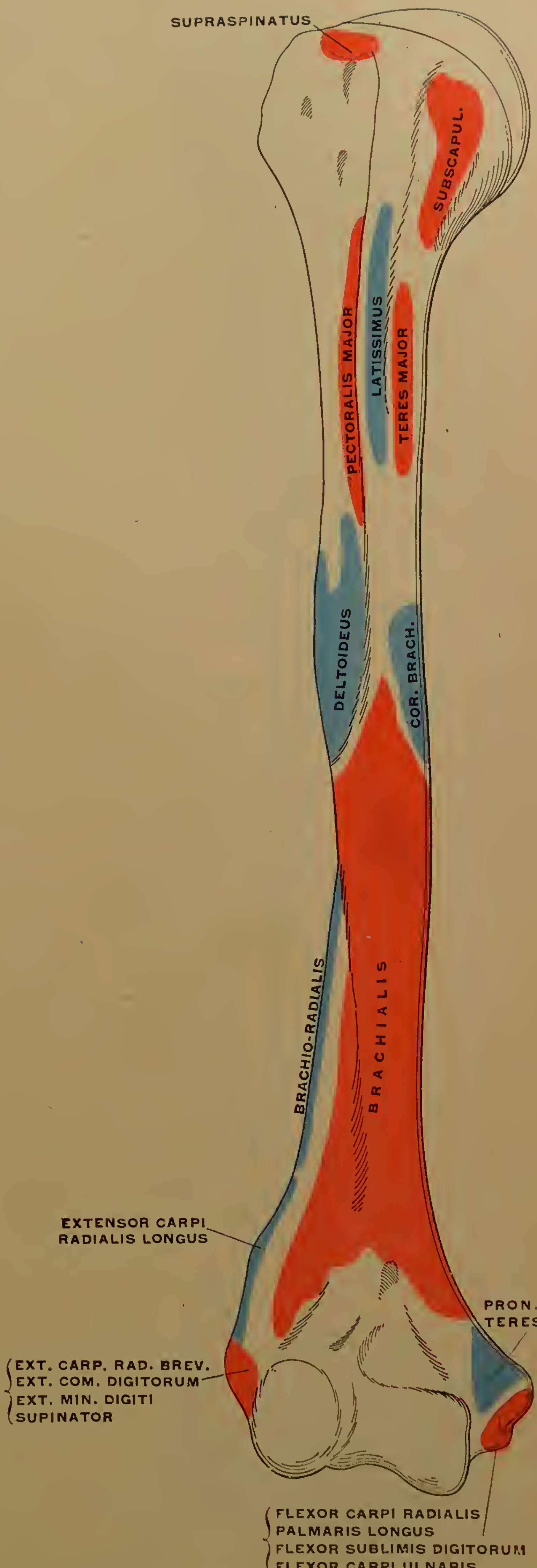


FIG. 165.—Areas of muscular attachment, ventral aspect of right humerus. (Testut.)

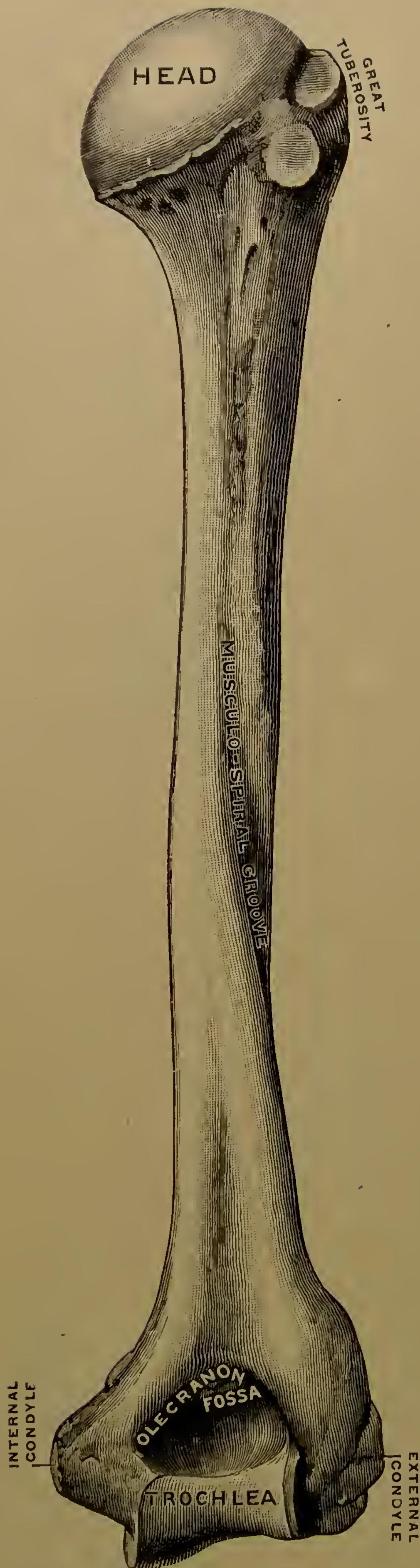


FIG. 166.—The right humerus, rear view. (Testut.)

FIG. 167.—Areas of muscular attachment, dorsal surface of right humerus. (Testut.)

the outer surface of the shaft nearly to the level of the head. Of the three facets on its upper and dorsal aspect, the upper gives insertion to the supraspinatus, the middle to the infraspinatus, and the lower to the teres minor muscle. The prominent *small tuberosity* looks forward and gives insertion to the subscapularis muscle. The *surgical neck*, so called from the frequency of fracture here, is where the shaft joins the upper extremity.

The *shaft*, cylindrical above, transversely expanded and triangular below, is twisted inward in descending. It presents external, internal, and dorsal surfaces separated by external, internal, and ventral borders. The *external* and *internal borders*, slightly marked above, become prominent below as the *external* and *internal supracondylar ridges*, which descend to the condyles. From each of these an intermuscular septum arises, and from the upper two-thirds of the external ridge arises the brachio-radialis muscle, and from its lower third the extensor carpi radialis longus. The *external border* extends down from the back of the great tuberosity, and is interrupted near the middle of the shaft by the musculo-spiral groove. The *internal border* commences above just below the head,[1] and near its centre presents a rough impression, extending on to the adjacent inner surface, for the coraco-brachialis muscle. The *ventral border* starts above from the front of the great tuberosity as the outer lip of the bicipital groove, and ends below in the ridge separating the trochlea and capitellum. The *internal surface* in its upper third presents the vertical *bicipital groove*, which lodges the long tendon of the biceps. Its two rough lips give insertion, the outer to the pectoralis major, the inner to the teres major below, and above to the latissimus, which is also attached to the floor of the groove. A little below the centre is seen the *nutrient foramen*, directed downward. The *external surface* presents just above the centre a rough V-shaped impression for the deltoid insertion, immediately below which the *musculo-spiral groove* is seen winding downward and forward after grooving the outer border. The hind or lower portion of this groove is traversed by the musculo-spiral nerve and the superior profunda vessels, while its upper part, together with the lower half of the external and internal surfaces and of the ventral border, gives origin to the brachialis muscle. The *dorsal surface*, unequally divided by the musculo-spiral groove, gives origin above the latter to the external head of the triceps, and below it to the internal head.

The *lower extremity* is transversely elongated, flattened from before backward, and curved forward. From within outward notice the following parts: The prominent *internal condyle* is flattened and inclined slightly backward, forming a shallow groove behind, traversed by the ulnar nerve. From the front of its extremity arise the pronator radii teres and the common tendon of the superficial flexor muscles in the forearm, below which the internal lateral ligament is attached. The *articular surface* is divided by a ridge (which corresponds to the interval between the radius and ulna) into a large internal and a smaller external part. The internal part, or *trochlea* ("pulley"), is a pulley-like surface, grooved in the middle, which articulates with the great sigmoid cavity of the ulna. It is obliquely placed, so that it extends upward and outward behind, and its inner margin descends much lower than its outer. It is broader behind than in front, and its surface forms three-fourths or more of a circle. Above it notice the large *olecranon fossa* behind and the smaller *coronoid fossa* in front, receiving, respectively, the olecranon process in extension and the coronoid process in forced flexion of the forearm. The external part, the *capitellum* ("little head"), or *radial head*, is a small rounded surface, which, with the groove internal to it, articulates with the head of the radius. It looks forward, and is confined to the ventral and a part of the inferior surface. Above it in front is a slight depression for the edge of the head of the radius in complete flexion of the elbow. The *external condyle* is on the same horizontal plane with, but less prominent than, the internal. To it is attached inferiorly the common tendon of the forearm extensor muscles, the external lateral ligament, and, more dorsally and internally, the anconeus muscle.

[1] It is usually described as containing the inner lip of the bicipital groove.

In its natural position the humerus is twisted inward so much that the internal condyle, which is in line with the head above, looks more backward than inward. The principal or longest axes of the upper and lower extremities make an angle of torsion of 30° with one another, which represents the amount of twisting of the bone. The humerus averages 13 inches in length in the male and 12 inches in the female. The condyles alone are subcutaneous, and are important as landmarks.

Varieties.—The thin plate of bone between the olecranon and coronoid fossæ is sometimes perforated, forming the *supratrochlear foramen.* A small hook-like *supracondylar process,* connected by a fibrous band with the internal condyle about 2 inches below it, is occasionally found. It represents a similarly placed bony foramen in many animals, and, like it, transmits through the arch the median nerve and often the brachial artery or a large branch of it.

Ossification occurs from a primary centre in the shaft and six or seven secondary centres in the extremities. In the upper extremity centres appear in the head, great tuberosity, and sometimes in the small tuberosity, which, after fusing together, join the shaft about the twentieth year. In the lower extremity centres appear in the trochlea, capitellum, and outer and inner condyles, the three former of which, after coalescing, unite with the shaft in the seventeenth year. The inner condyle forms a distinct epiphysis which unites somewhat later.

THE ULNA.

The *ulna* ("elbow-bone") (Figs. 168, 170), the inner bone of the forearm, is parallel with, but longer than, the radius by nearly the length of the olecranon. It is inclined downward and outward from the humerus, so that the great tuberosity and capitellum of the humerus and the lower end of the ulna are in a straight line.

The irregular *upper extremity* is the thickest part, and presents for articulation with the trochlea of the humerus the *great sigmoid* ("sigma-like") *cavity.* This looks forward and upward, is concave from above downward, and presents a longitudinal ridge which fits into the groove of the trochlea. At the middle of the cavity is a constriction (sometimes a groove) which represents the limit between the upper and hind part formed by the olecranon, and the lower and fore part formed by the coronoid process.

The thick *olecranon* ("elbow-head") *process* forms the highest part of the ulna. On its broad upper surface the triceps is inserted dorsally, while the front of this surface projects in a beak which overhangs the great sigmoid cavity, and fits into the olecranon fossa of the humerus in extension of the elbow. The dorsal surface is triangular and subcutaneous, except for a bursa covering it. The margins of the ventral or articular surface give attachment to the internal and posterior ligaments of the elbow. From a tubercle on its inner side part of the flexor carpi ulnaris arises. The *coronoid* ("crown-like") *process* projects forward from the upper end of the shaft. Its sharp ventral edge, or *apex,* is received into the coronoid fossa of the humerus in flexion. The ventral and internal edges of its upper or articular surface give attachment to the anterior and internal ligaments of the elbow, respectively. The antero-inferior surface is rough, and, together with the *tuberosity* at its lower end, gives insertion to the brachialis. The oblique ligament is attached to the outer part of the tuberosity. On the inner edge of this surface is a tubercle from which part of the flexor sublimis digitorum arises, and from the ridge below it parts of the pronator radii teres and flexor longus pollicis arise. On the outer side of the upper end of the coronoid process, and continuous with the great sigmoid cavity, is the concave, oval, *small sigmoid cavity* for articulation with the side of the head of the radius.

The *shaft* tapers from above downward. It is curved inward above, outward below, as well as slightly backward. Triangular in the upper three-fourths, more rounded below, it presents the following parts: The *anterior* or *ventral border* runs

from the inner margin of the coronoid process to the front of the styloid process, becoming continuous in its lower fifth with the oblique pronator ridge. The *posterior* or *dorsal border* begins at the apex of the subcutaneous triangle behind the olecranon, and runs sinuously to the back of the styloid process, becoming less distinct below. The *external* or *interosseous border*, faintly marked below, is sharply marked in the middle, and gives attachment to the interosseous membrane. It bifurcates above into two lines which pass to the two ends of the small sigmoid cavity, and enclose a triangular space which, with its prominent dorsal border, called the *supinator ridge*, gives origin to the supinator muscle. The *ventral surface* gives origin in the concave upper three-fourths to the flexor profundus digitorum, and in the lower fourth, below the oblique *pronator ridge*, to the pronator quadratus. In the middle third is the *nutrient foramen*, directed upward.

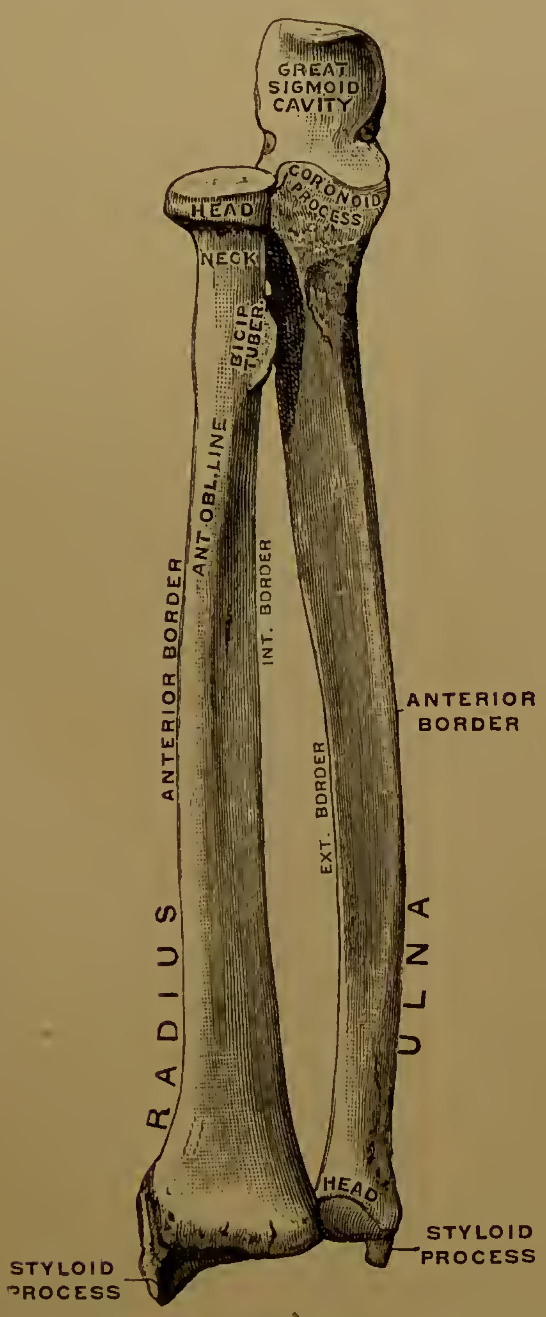


FIG. 168.—The bones of the right forearm, ventral view. (Testut.)

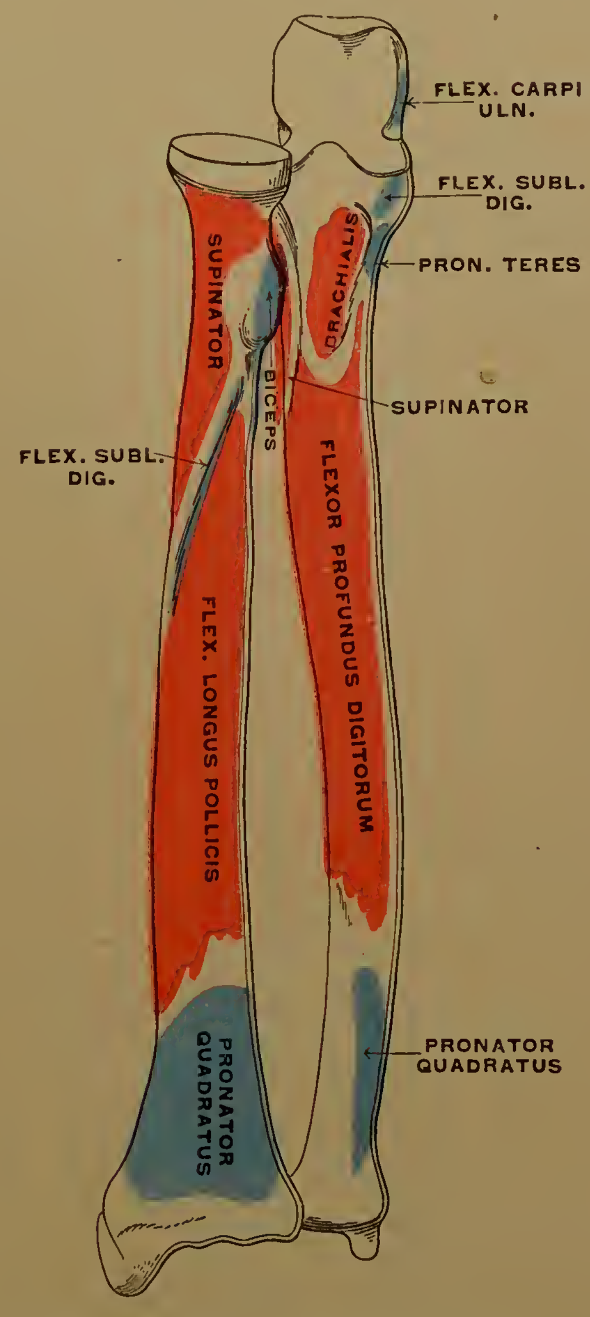


FIG. 169.—Areas of muscular attachment, ventral aspect of the radius and ulna.

The *internal surface* gives origin to the flexor profundus digitorum in its upper three-fourths, below which it is subcutaneous. The *dorsal surface* is inclined slightly outward. To a triangle on its upper fourth, marked off by an oblique line from the supinator ridge to the dorsal border, the anconeus is inserted behind and internal to the supinator triangle. Below this a vertical ridge separates an internal area, covered by the extensor carpi ulnaris, from an external area, from which arise in order from above downward the extensor ossis metacarpi pollicis, the extensor longus pollicis, and the extensor indicis.

The *lower extremity* is small, and presents (1) a rounded *head* with a flattened, semilunar articular facet inferiorly, which plays upon the triangular fibro-cartilage, and a convex facet externally received into the sigmoid cavity of the

radius; (2) the cylindrical *styloid* ("pillar-like") *process*, which descends from the inner and back part of the head. To its extremity is attached the internal lateral ligament, and to the depression at the outer side of its base the triangular fibro-cartilage. In the groove behind and between it and the head glides the tendon of the extensor carpi ulnaris.

The *subcutaneous parts* are the triangular hind surface of the olecranon, the dorsal border, the lower fourth of the inner surface, the styloid process, and, in pronation, the outer and fore part of the head. Notice that the ulna does not articulate directly with the carpus.

Ossification occurs in cartilage from one primary centre for the shaft. The upper end of the olecranon, ossified from a secondary centre, joins the shaft in the sixteenth or seventeenth year. The lower extremity, ossifying from an earlier formed centre, joins the shaft from about the eighteenth to the twentieth year.

THE RADIUS.

The *radius* ("spoke"), the outer bone of the forearm, takes little part in the elbow-, but the principal part in the wrist-joint, articulating with the scaphoid, semilunar, and ulna below, the humerus and ulna above.

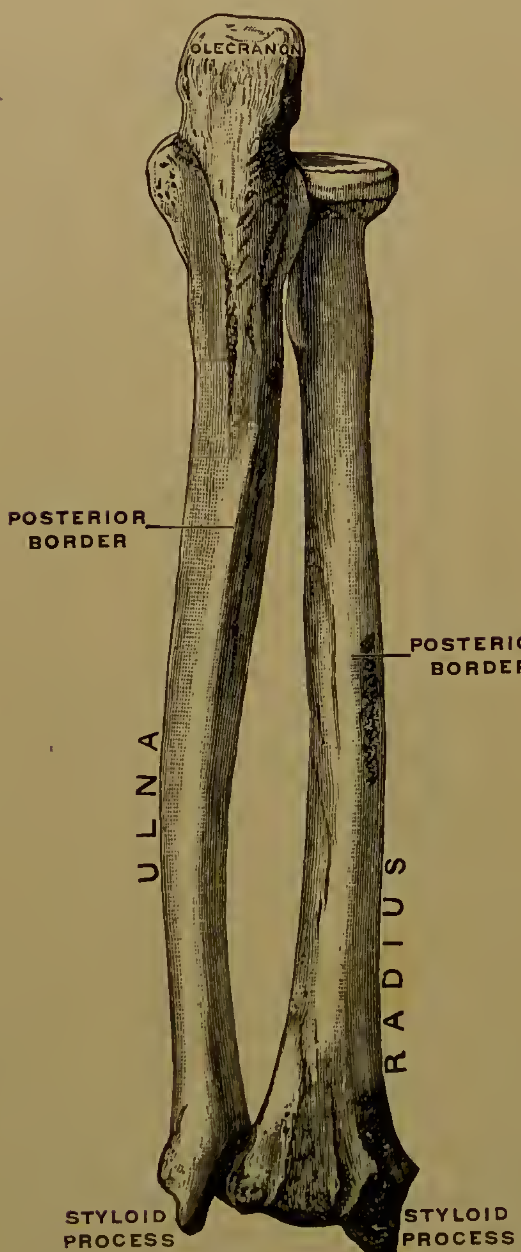


FIG. 170.—The bones of the right forearm, dorsal view. (Testut.)

FIG. 171.—Areas of muscular attachment, dorsal aspect of radius and ulna.

The disc-shaped *upper extremity*, or *head*, presents, superiorly, a shallow articular depression with an encircling rim, which articulate respectively with the capitellum of the humerus and the groove internal to it. Owing to the ventral

position of the capitellum, contact between the latter and the radius is most intimate in flexion of the elbow. Its smooth, short, vertical margin is deeper internally, where it articulates with the small sigmoid cavity of the ulna, than externally, where it is embraced by the orbicular ligament. Below the head is a constricted *neck*, which is continuous with the shaft opposite the *bicipital tuberosity*. The latter, situated ventro-internally, has a rough dorsal portion for insertion of the biceps tendon and a smoother ventral part covered by a bursa.

The *shaft* is triangular, curved outward and slightly backward, and becomes larger below. The *internal* or *interosseous border*, commencing below the bicipital tuberosity, is prominent in the middle three-fifths, and divides in the lower fifth into two lines, which pass to the two ends of the sigmoid cavity. The interosseous membrane is attached to it. The *ventral* or *anterior* and the *dorsal* or *posterior borders*, commencing also at the tuberosity, pass obliquely downward and outward as the *ventral* (*anterior*) and *dorsal* (*posterior*) *oblique lines* to the junction of the upper and middle thirds, and thence descend to the front and back of the styloid process, becoming less marked below. To the ventral oblique line the flexor sublimis digitorum is attached. The area between the two oblique lines, externally, gives insertion to the supinator as far down as the rough impression for the pronator teres, situated about the middle and at the most prominent part of the *external surface*. Below this point the external surface is covered by the extensor tendons. The *ventral surface* gives origin in its upper two-thirds to the flexor longus pollicis, and its lower fourth gives insertion to the pronator quadratus. The *nutrient foramen*, directed upward, is seen above the middle of this surface. The *dorsal surface* in the middle third gives origin to the extensor ossis metacarpi pollicis above and to the extensor brevis pollicis below. Its lower third is covered by extensor tendons.

The *lower extremity* is broad, thick, and quadrilateral. The large *inferior* or *carpal surface*, concave and triangular, is divided by a ridge into an outer triangular surface, which articulates with the scaphoid, and an inner quadrilateral surface, which articulates with the semilunar. At the lower end of the inner surface is the narrow *sigmoid cavity*, concave from before backward, which articulates with the head of the ulna. It is at right angles to the carpal surface, and the smooth margin between them gives attachment to the base of the triangular fibro-cartilage. A transverse ridge at the lower end of the *ventral surface* limits the attachment of the pronator quadratus, and to it and the narrow space below it the anterior ligament of the wrist-joint is attached. The *outer* or *dorso-external surface* is prolonged downward onto the stout, pyramidal, subcutaneous *styloid process*. The latter is lower than the styloid process of the ulna, and is an important landmark in diagnosticating fractures. To its tip is attached the external lateral ligament, and to its base the brachio-radialis muscle. Two grooves, separated by a ridge, are seen on this surface; the ventral one gives passage to the tendons of the extensor ossis metacarpi pollicis and the extensor brevis pollicis; the dorsal and inner one, sometimes subdivided by a low ridge, gives passage to the tendons of the extensores carpi radiales longus and brevis. The *dorsal surface* extends lower than the ventral, and of its two grooves the narrow external one for the extensor longus pollicis is separated from the last-mentioned groove on the outer surface by a prominent subcutaneous tubercle. The inner dorsal groove transmits the extensor communis digitorum and the extensor indicis tendons. The posterior annular ligament converts these grooves into canals by its attachment to the dividing ridges, the styloid process, and the inner margin.

The radius is more deeply placed than the ulna. In supination the two bones are parallel; in pronation the radius crosses the ulna.

Ossification proceeds from one primary centre in the shaft, a secondary centre in the head, which joins the shaft in the seventeenth year, and a secondary centre in the lower extremity, which appears first, but does not ankylose with the shaft until the twentieth year.

THE BONES OF THE HAND.

The skeleton of the hand is composed of the bones of the carpus and metacarpus, and the phalanges, forming the skeleton of the wrist, the palm, and the digits, respectively.

THE CARPAL BONES.

The eight carpal bones (Figs. 172–176) are arranged in two rows of four each. The carpus is transversely convex on the dorsal surface, and concave on the palmar surface. On the palmar surface, at the inner and outer extremities of each row, there is a prominence giving attachment to the anterior annular ligament, which completes a canal for the flexor tendons and the median nerve. The upper surface of the upper row is convex, articulating with the concavity of the radius and the triangular fibro-cartilage. The convexity extends onto the dorsal more than onto the palmar surface. In the line of articulation between the two rows the convexity of the os magnum and unciform is received into the concavity of the bones of the first row, and the convexity of the scaphoid is received into the slight concavity of the trapezium and trapezoid. The lower surface of the lower row is irregularly transverse and articulates with the metacarpus. In general the carpal bones are short and irregularly cuboidal. The dorsal surfaces, usually the larger, and the palmar surfaces, more irregular, are rough for ligamentous attachments. As a rule, the upper and lower, and outer and inner surfaces of these bones are articular, to articulate with the bones above and below and on either side; but a lateral surface of the terminal bones of each row is non-articular. Enumerated from the radial to the ulnar side, the upper row consists of the scaphoid, semilunar, cuneiform, and pisiform; and the lower row of the trapezium, trapezoid, os magnum, and unciform. The principal individual points of the separate bones are as follows:

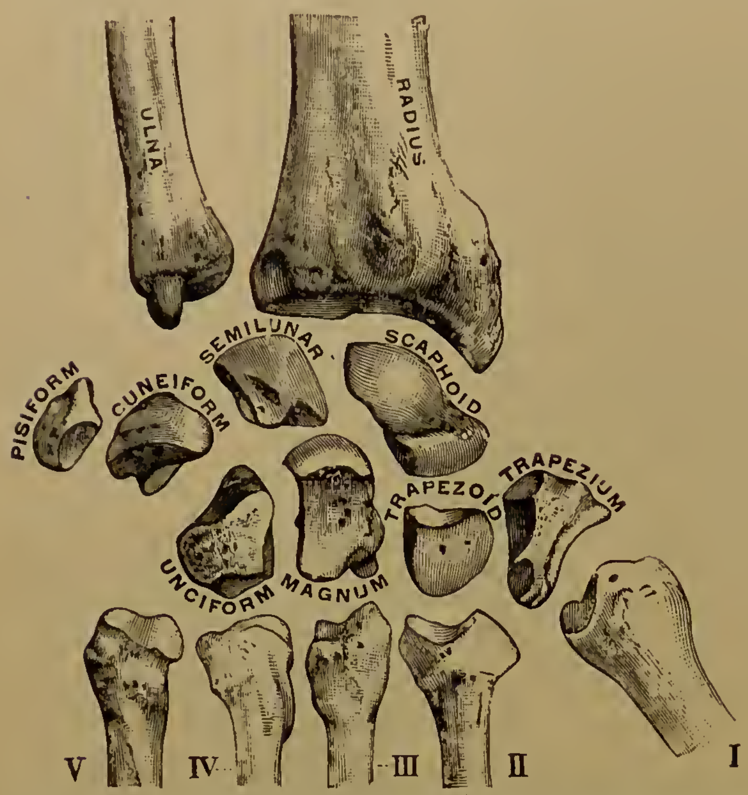


FIG. 172.—The bones of the right carpus, the distal ends of the forearm bones, and the proximal ends of the metacarpal bones, dorsal aspect. (Testut.)

The Scaphoid.

The *scaphoid* ("boat-like"), the largest bone of the upper row, is elongated downward and outward. Of the three articular surfaces, the upper is convex and triangular, articulating with the radius; the lower is convex for the trapezium externally and the trapezoid internally; and the internal is concave below for the os magnum, flat and crescentic above for the semilunar. The outer end or surface is prolonged forward into a strong conical *tuberosity*, which gives attachment to the annular ligament. The dorsal surface is a mere groove providing attachment for the posterior ligaments of the wrist.

The Semilunar.

The *semilunar* ("half-moon") presents four articular surfaces, of which the upper is convex for the radius; the lower is concave for the os magnum, and, near its inner margin, for the unciform; the external is crescentic and narrow for the scaphoid; and the internal is quadrilateral and larger for the cuneiform.

The Cuneiform.

The *cuneiform* (" wedge-shaped ") or *pyramidal bone* is placed with its blunted apex directed downward and inward. This bone also presents four articular facets. The base articulates with the semilunar. The upper surface is convex

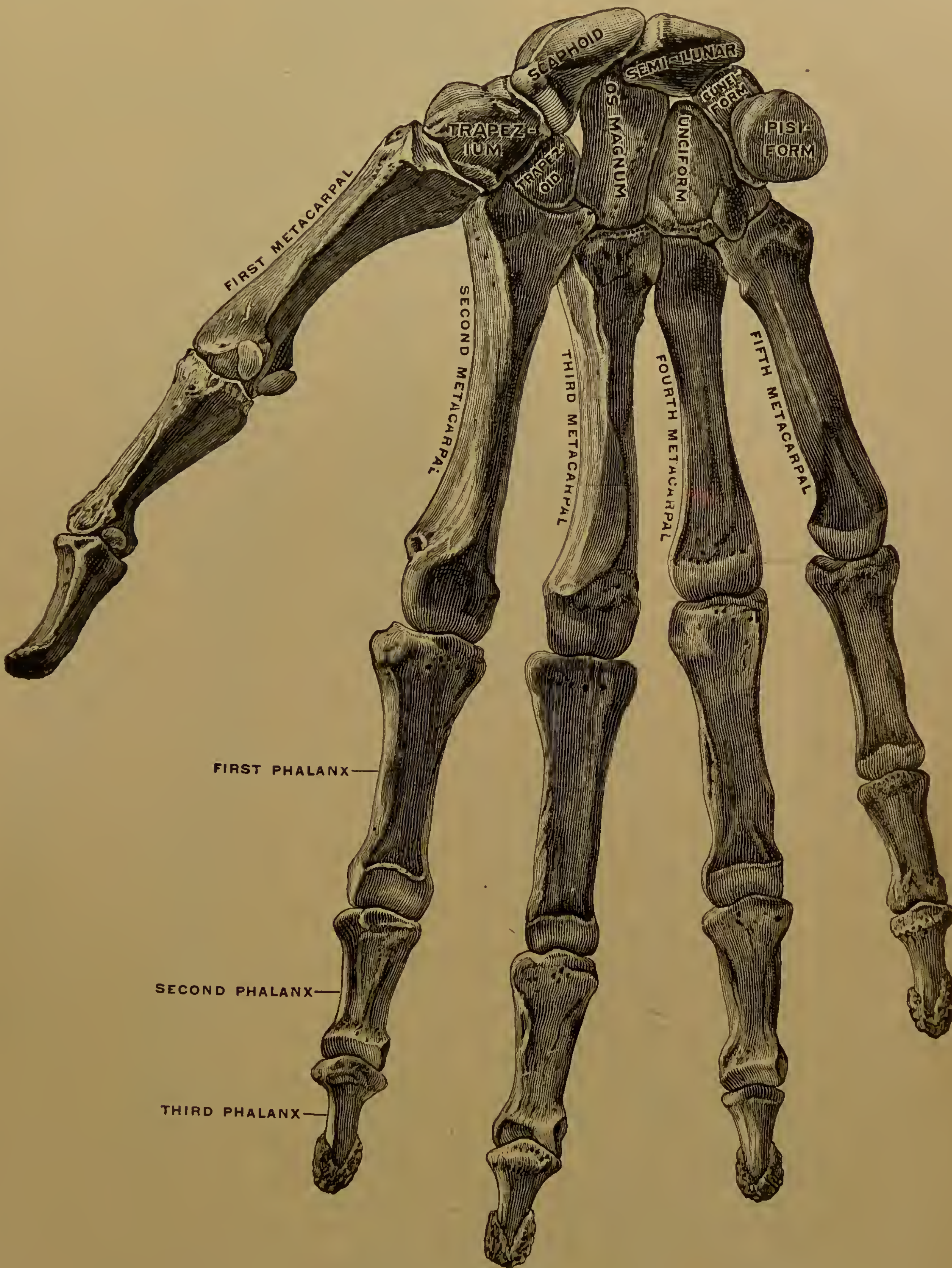


FIG. 173.—The bones of the right hand, palmar aspect. (Spalteholz.)

and smooth externally for the triangular fibro-cartilage, rough internally for ligaments. The lower surface is concavo-convex for the unciform. On the palmar surface near the apex is a circular facet for the pisiform bone. The internal lateral ligament of the wrist is attached to the apex.

The Pisiform.

The *pisiform* ("pea-shaped") bone is vertically spheroidal, and has a single oval articular facet dorsally for the cuneiform. The rest of the bone projects forward as one of the internal eminences for the anterior annular ligament, and gives insertion to the flexor carpi ulnaris. The outer side is slightly concave.

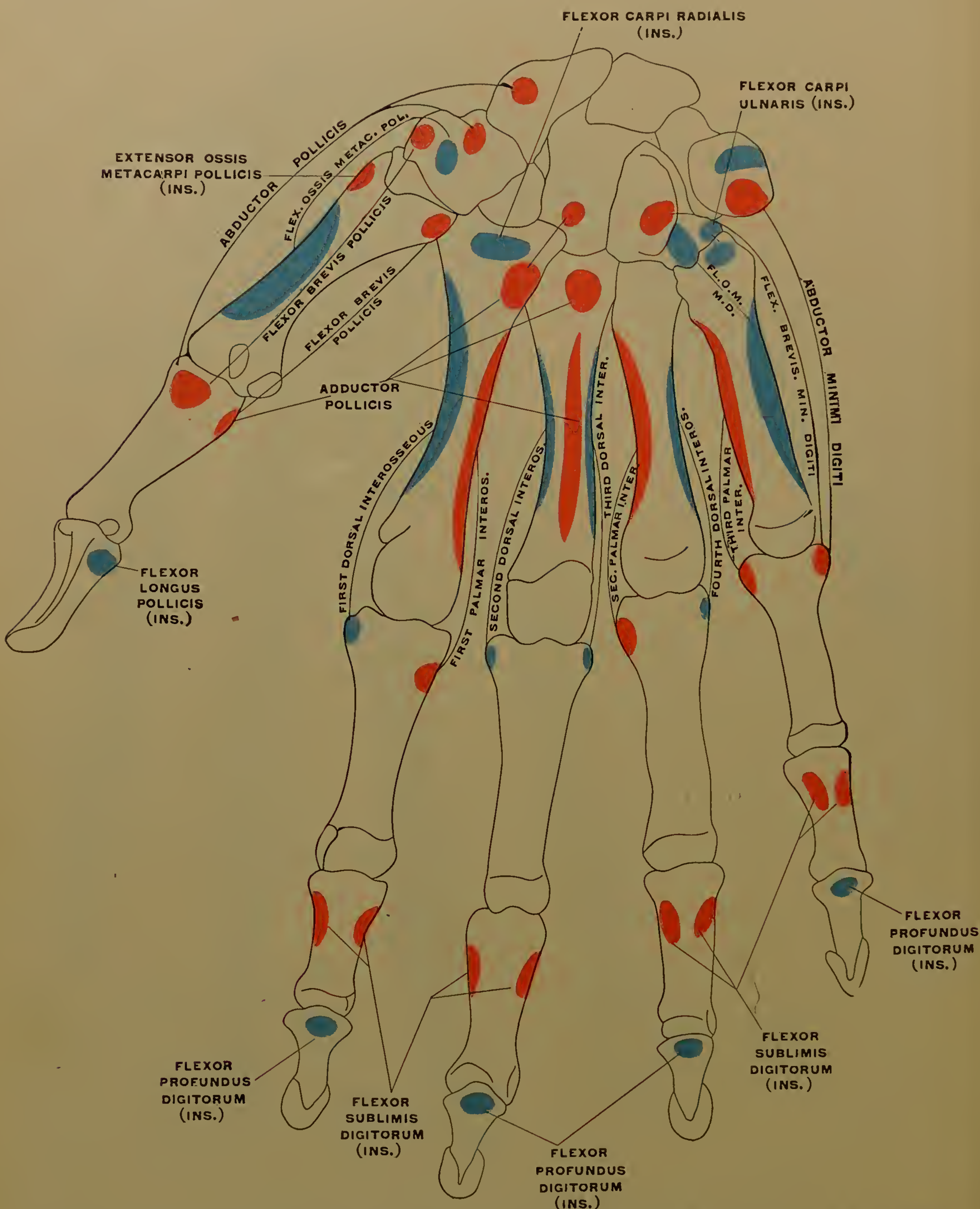


Fig. 174.—Areas of muscular attachment on the palmar surface of the bones of the hand. Where the areas of origin and insertion are both presented, they are in the same color. INS. = insertion. FL.O.M.M.D. = flexor ossis metacarpi minimi digiti.

The Trapezium.

The *trapezium* ("table"), rhombic in form, is the most external bone of the lower row, and therefore has but three articular surfaces—a superior, slightly con-

cave, for the scaphoid; an inferior, saddle-shaped, for the base of the first metacarpal bone; and an internal, divided by a ridge into an upper and larger one for the trapezoid and a lower and smaller for the base of the second metacarpal bone. On the palmar surface there is a vertical groove for the passage of the flexor carpi

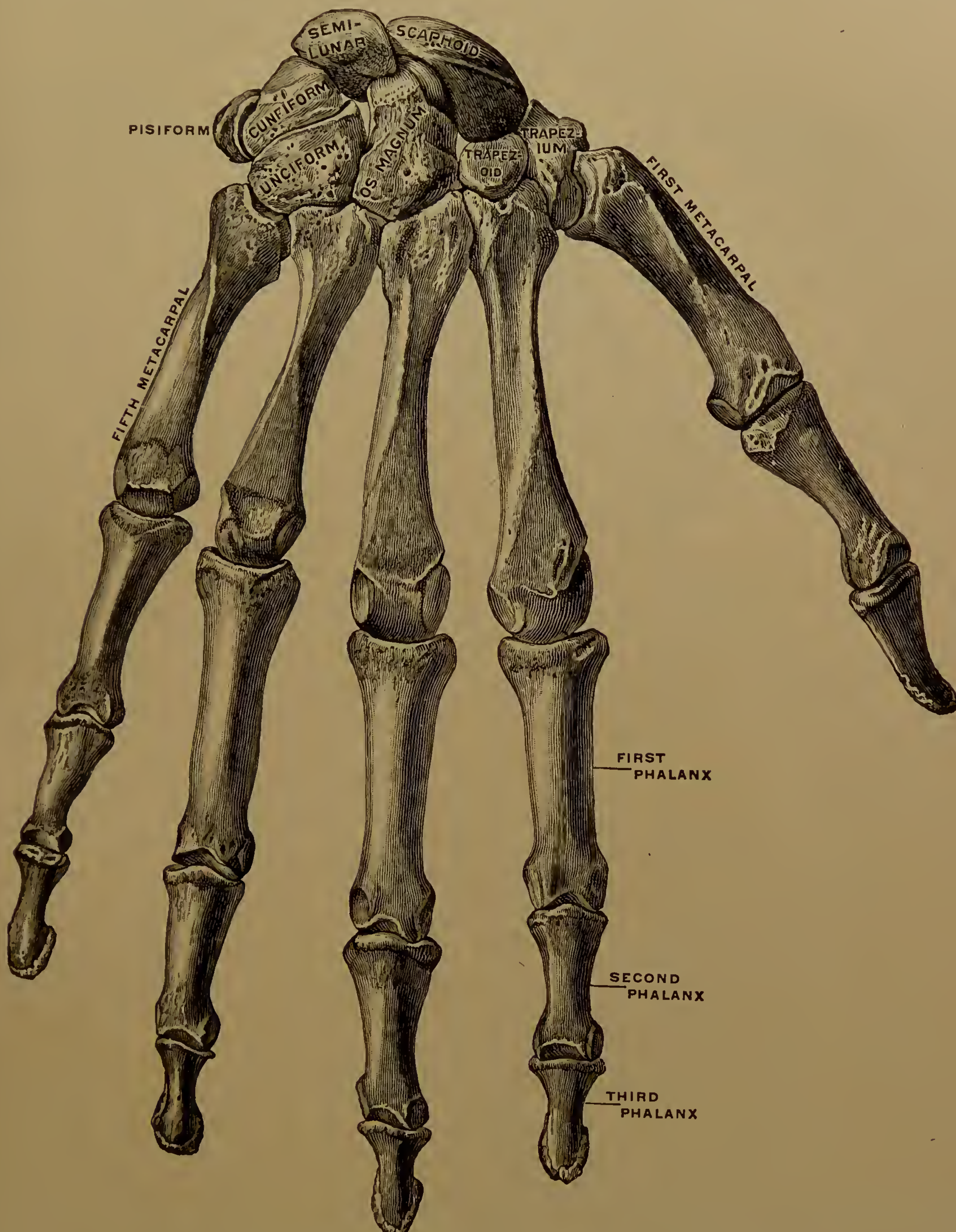


FIG. 175.—The bones of the right hand, dorsal aspect. (After Spalteholz.)

radialis tendon, and external to this a ridge or *tuberosity* forming the second external prominence for the attachment of the anterior annular ligament.

The Trapezoid.

The *trapezoid* ("table-like"), the smallest bone of the lower row, has its longest diameter from before backward. Its dorsal surface is much larger than

the palmar; its four articular surfaces are nearly continuous, and present superiorly a small, concave, triangular facet for the scaphoid; inferiorly, a long

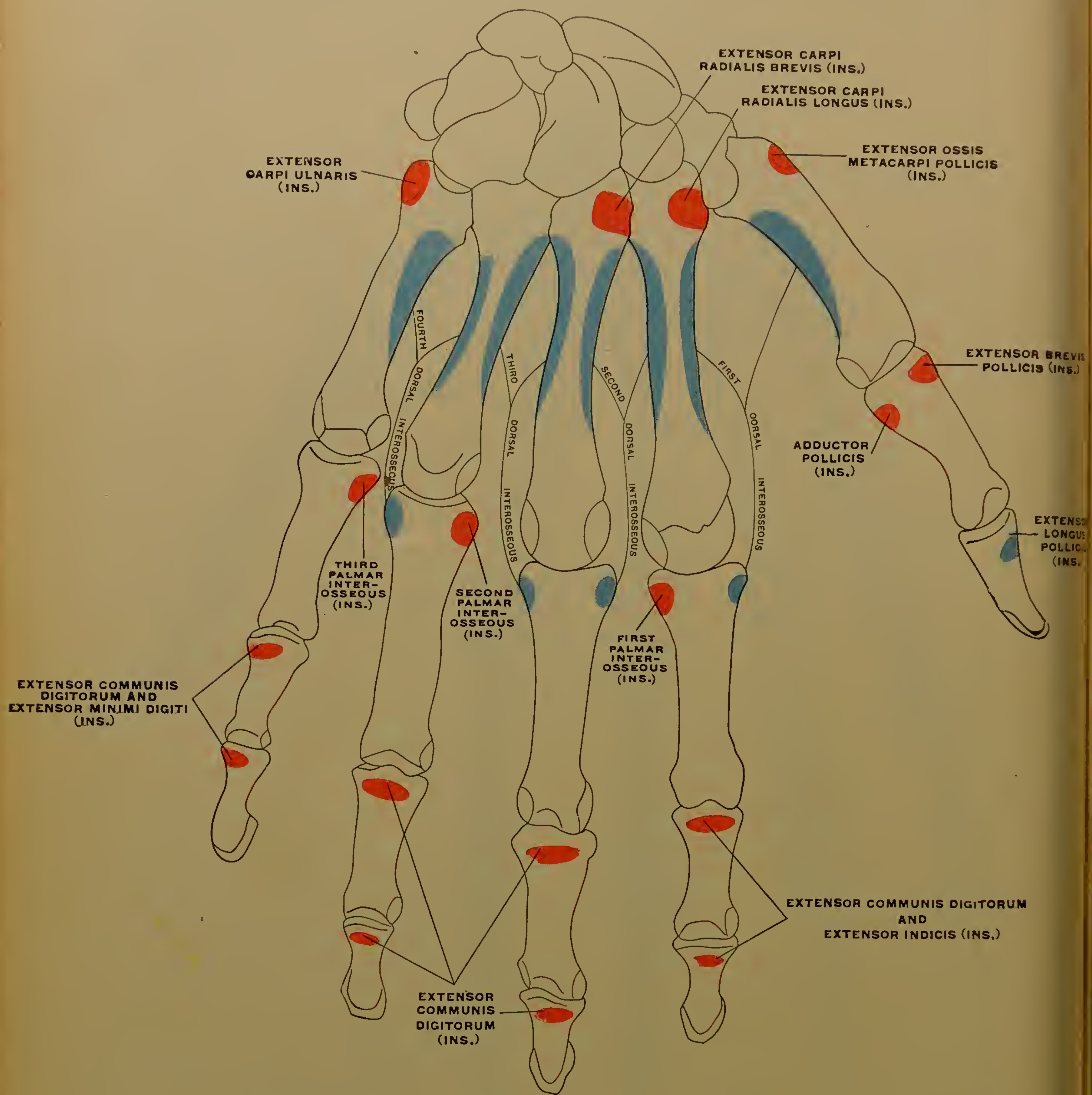


FIG. 176.—Areas of muscular attachment on the dorsal surface of the bones of the hand. Where the areas of origin and insertion are both presented, they are in the same color. INS.= insertion.

saddle-shaped facet for the second metacarpal bone; externally, a convex facet for the trapezium; and internally, a facet for the os magnum.

The Os Magnum.

The *os magnum* ("great bone"), the largest carpal bone, is elongated vertically, and occupies the centre of the wrist. It presents above a rounded *head* joined by a slightly constricted *neck* to a quadrilateral *body* below. It articulates

above by its rounded head with the socket formed by the scaphoid and semilunar; below, by three facets, of which the middle is the largest, with the second, third, and fourth metacarpal bones; externally, with the trapezoid by a small facet below that for the scaphoid; and internally, by an elongated facet, sometimes two facets, with the unciform. Its broad dorsal surface is larger than the palmar, and is prolonged downward and inward.

The Unciform.

The *unciform* ("hook-shaped") is named from a large flattened hook-like process, concave externally, which projects forward from its palmar surface and gives attachment at its apex to the anterior annular ligament. Triangular in form, it articulates above by a narrow facet on its apex with the semilunar, below by two facets with the fourth and fifth metacarpal bones; externally with the os magnum, and internally by a concavo-convex facet inclined upward with the cuneiform, leaving but a narrow non-articular surface on the inner side.

The carpal bones afford origin by their palmar surfaces to most of the short muscles of the thumb and little finger.

Ossification occurs for each bone from a single centre, which appears after birth. The cartilaginous *os centrale,* situated dorsally between the scaphoid, os magnum, and trapezoid in the fœtus, is occasionally ossified separately, but usually coalesces with the scaphoid.

THE METACARPAL BONES.

The *metacarpus* ("beyond the carpus") (Figs. 173, 175) contains five long bones, which support the fingers and form the skeleton of the palm. They diverge somewhat from each other below, and form the hollow of the palm by being slightly curved longitudinally, and by articulating with the transversely curved carpus. They are numbered from without inward. The first is the broadest and shortest, the second the longest, and the rest decrease in length from the third to the fifth.

General Characteristics.—The *upper end* or *base* is irregularly cuboidal, and presents two non-articular, rough surfaces for ligamentous and muscular attachments, a broader dorsal and a narrower palmar surface; and three articular surfaces, an upper for the carpus, and an inner and an outer for articulation and ligamentous union with each other. The *shaft* is triangular and slightly curved, with its concavity in front. On the dorsal surface a ridge starts at the carpal end, and divides into two lines, each of which ends in a *dorsal tubercle* on the side of the head, the two lines enclosing a triangular, flattened surface covered by the extensor tendons. The dorsal surface on the sides of the ridge gives origin to the dorsal interossei muscles. The two lateral surfaces, separated from one another by a palmar ridge, afford attachment to the palmar interossei muscles. The carpal end of the shaft is the most slender part. The shaft of the first metacarpal is broad and flattened, its dorsal surface is smooth, and its palmar aspect looks inward. The *head* presents a rounded articular surface for articulation with the first phalanx. This articular surface is broader and extends farthest on the palmar aspect of the head, where it projects into two lateral cornua, or *palmar tubercles,* separated by a groove for the flexor tendons. The sides of the head are flattened, and marked by a depression for the lateral ligaments. The articular surface of the head of the first metacarpal bone is flatter than that of the others, and its two prominent palmar tubercles are for the two sesamoid bones in the flexor brevis pollicis tendons.

Special Characteristics.—Besides those above given, these concern mainly the *bases* or carpal extremities. That of the *first metacarpal* has a saddle-shaped facet for the trapezium and no lateral facet, but a tubercle externally for the extensor ossis metacarpi pollicis. That of the *second metacarpal* has no external lateral

facet, and three superior facets—a large, concave, central one for the trapezoid, and marginal ones for the os magnum and trapezium. Dorsally, near the external angle it has a tubercle for the extensor carpi radialis longus. That of the *third* has a prominent projection, the styloid process, at the outer and upper angle of the dorsum, below which the extensor carpi radialis brevis is inserted. That of the *fourth* has two facets externally, corresponding to two internally on the *third*, and, besides the main facet for the unciform above, there is a small facet for the os magnum on the outer angle dorsally. The base of the *fifth* has no facet internally, but a tuberosity for the extensor carpi ulnaris. Its upper end is saddle-shaped and directed slightly outward.

Ossification of the metacarpal bones and phalanges proceeds from one primary centre in the shaft, and a secondary centre in the base of the first metacarpal bone and of the phalanges and in the head of the other metacarpals. The secondary centre joins the shaft by the twentieth year. In the terminal phalanges the shaft centre begins in the distal end.

THE PHALANGES.

Of the fourteen phalanges ("ranks") (Figs. 173, 175), each finger contains three and the thumb two. Like all long bones, they have two extremities and a shaft. The *shafts*, semi-cylindrical, are convex dorsally, and the rough margins of the flat palmar surfaces give attachment to the sheaths of the flexor tendons. The five of the *first row* are the longest, and are slightly curved longitudinally. The thicker upper end, or *base*, has a transversely elongated, concave articular facet (*glenoid cavity*), and the *distal end*, flattened from before backward, has a facet prolonged onto the palmar aspect, and divided into two condyles by a groove. The four of the *second row*, that of the thumb being wanting, are smaller, but similar, except that the proximal articular facet has a slight median ridge and two lateral depressions to fit the condyles of the first row. The five *terminal* or *ungual* (from *unguis*, "a nail") *phalanges* have proximal extremities like those of the second row, with the addition of a palmar depression for the long flexor tendons. The shaft tapers to the flattened, expanded, horseshoe-shaped distal extremity, of which the smooth dorsal surface supports the nail, and the rough palmar surface the pulp of the finger.

Taken together, the phalanges of the middle finger are the longest, and next those of the ring, index, little finger, and thumb, in the order named.

THE BONES OF THE LOWER LIMB.

The bony pelvis includes, besides the sacrum and coccyx, already described, the two hip-bones which form the *pelvic girdle*. Besides the hip-bones, the skeleton of the lower limb comprises the femur in the thigh, the tibia and fibula in the leg, and the tarsal, metatarsal, and phalangeal bones in the foot. A large sesamoid bone, the patella, is found at the knee.

THE HIP-BONE.

The *hip-bone* (*os coxæ*), or *os innominatum* ("unnamed bone") (Figs. 177, 179), is irregular in form and shaped somewhat like the blade of a screw-propeller. It is narrowed in the middle, where the *acetabulum*, or socket for the femur, is seen externally, and expanded above and below. The large upper portion forms the *false pelvis* ("basin"), a part of the abdominal wall; the lower portion, perforated by the large *thyroid* ("shield-like") or *obturator* ("stopper") *foramen*, forms the lateral and front parts of the *true pelvis*, and curves inward to meet its fellow. The hip-bone transmits the weight of the body to the femur. The three parts,

ilium, ischium, and *os pubis,* separate in early life, ankylosed in the adult at the acetabulum, where they meet, are conveniently recognized as distinct in the description of the bone. In following the description hold the posterior part of the notch in the acetabulum downward, in the natural position of the bone.

The Ilium.

The *ilium* ("twisted") is the large, upper expanded portion, whose lower limit forms the upper two-fifths of the acetabulum, and whose upper border, the *crest,* presents three lips for attachment of the flat muscles of the abdomen. The crest is sinuous, *ſ*-shaped, irregularly thickened, and subcutaneous.

To the outer lip are attached the tensor vaginæ femoris in front, the obliquus externus in the ventral half, the latissimus in the dorsal half, and the gluteal portion of the fascia lata in the entire length; to the middle ridge, the obliquus

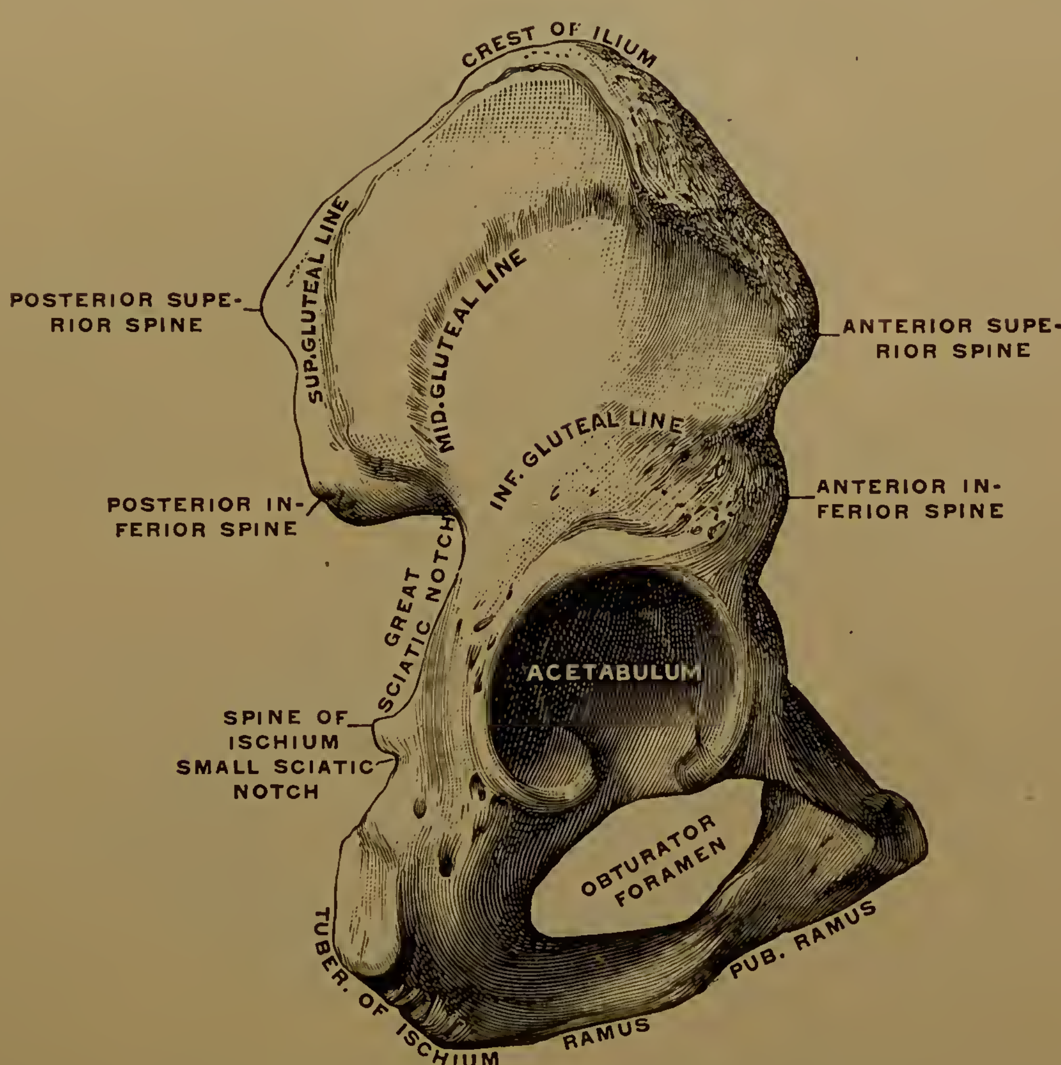


FIG. 177.—The right hip-bone, outer surface. (Testut.)

internus in the ventral two-thirds; to the inner lip, the transversalis in the ventral three-fourths, the quadratus lumborum and erector spinæ behind, and the iliac fascia in the entire length.

The crest ends in front in the prominent *anterior superior spine,* to which the inguinal (Poupart's) ligament, the tensor vaginæ femoris, and the sartorius are attached. The latter muscle extends onto the notch below, which transmits the external cutaneous nerve, and separates the superior from the *anterior inferior spine.* From the latter, situated above the acetabulum, the straight tendon of the rectus femoris and the ilio-femoral band of the hip-joint take origin. Below this spine and between it and the ilio-pectineal eminence, where the ilium and os pubis meet, is seen the *inferior iliac notch.* This is situated in front of, and above, the acetabulum, and is traversed by the ilio-psoas muscle.

The crest ends behind in the *posterior superior spine,* which affords ligamentous

attachment. It is separated by a slight notch from the *posterior inferior spine*, at the hindermost point of the auricular articular surface. Below the latter spine is the *great sacro-sciatic* ("sacro-ischiatic") *notch*, bounded above by the ilium, below and in front by the dorsal border of the ischium.

The *external surface*, or *dorsum*, flat or convex in front and behind, concave in the middle, is marked by the superior, middle, and inferior gluteal lines, which form the lower limit of the origin of the glutei maximus, medius, and minimus, respectively. The *superior gluteal line* begins at the crest about 2 inches in front of its dorsal end, and curves downward to the hind part of the great sciatic notch. To the lower part of the space behind it the pyriformis is often attached. The *middle gluteal line* curves backward and downward from the crest, 1 inch behind its anterior end, to the upper border of the great sciatic notch. The *inferior gluteal line* passes backward from just above the anterior inferior spine to the front of the great sciatic notch. Between the inferior gluteal line and the margin of

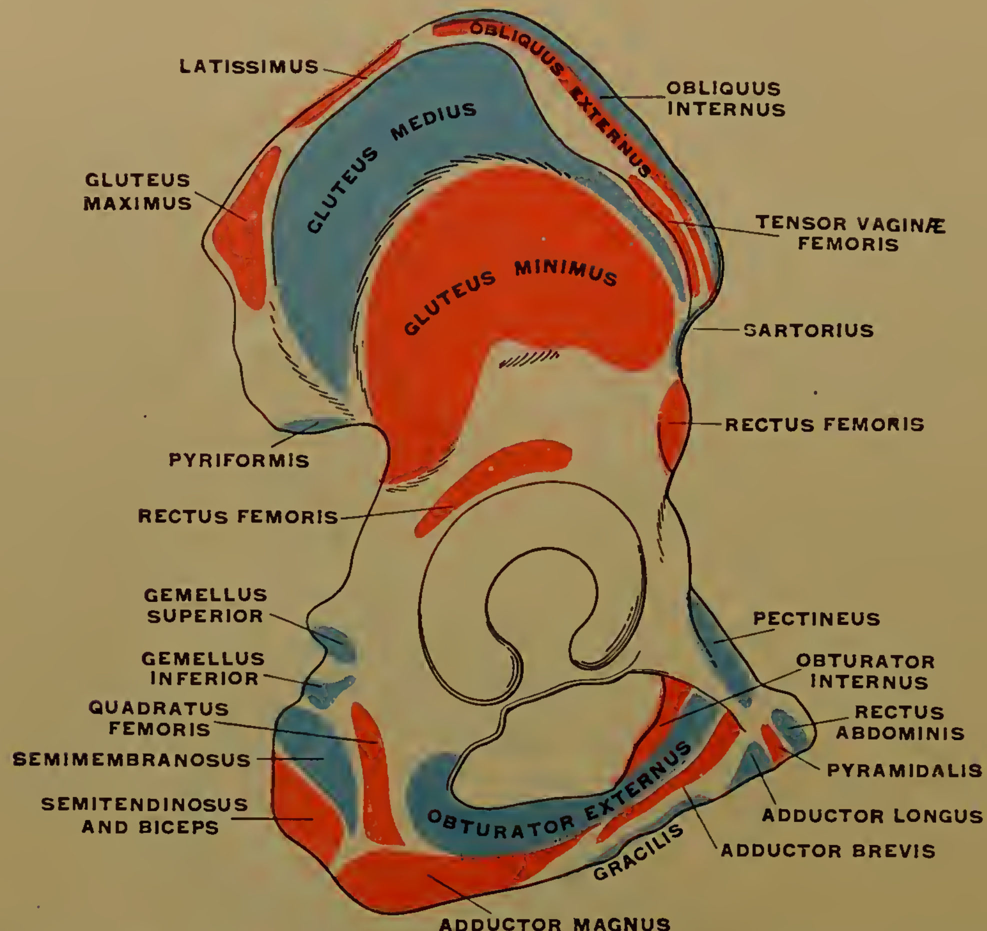


FIG. 178.—Areas of muscular attachment, outer surface of right hip-bone. (Testut.)

the acetabulum, and a little behind the anterior inferior spine, is a rough surface for the reflected tendon of the rectus femoris.

On the *internal surface* of the ilium is seen in front a smooth, concave, triangular area, the *iliac fossa*, giving origin to the iliacus muscle. A smaller, uneven surface behind this is divided into an inferior *auricular* ("ear-shaped"), cartilage-covered surface for articulation with the sacrum, and a superior rough surface for the attachment of the posterior sacro-iliac ligaments below and the erector spinæ above. The iliac fossa is limited below by the *ilio-pectineal* ("ilio-pubal") *line*, which forms the brim of the true pelvis, and extends between the auricular surface and the spine of the os pubis. Below the auricular surface and the dorsal end of the ilio-pectineal line is a small, smooth area of the ilium, which forms a small part of the wall of the true pelvis.

The Ischium.

The *ischium* ("hip") is situated dorso-inferiorly. Superiorly it forms two-fifths of the acetabulum on the dorsal and lower aspect, and nearly all of the non-articular part of its floor; and below, it terminates in the *tuberosity*. The latter is the thickest part of the bone, upon which the body rests in sitting, and from which the *ramus* ("branch") ascends to join that of the os pubis to assist in bounding the obturator foramen. The triangular upper part, or *body*, presents externally, between the acetabular rim and the tuberosity, a groove for the upper border of the obturator externus. Internally the body and the tuberosity form a flattened surface, which bounds the true pelvis laterally, and from which the obturator internus arises. The dorso-internal border of the body completes the great sacro-sciatic notch, which is limited below by the prominent *spine* of the ischium. To the spine the small sciatic ligament is attached dorsally, the coccygeus and levator ani internally, and the gemellus superior dorso-externally, where the spine is crossed by the internal pudic vessels and nerve. The cartilage-clad small sciatic notch, over

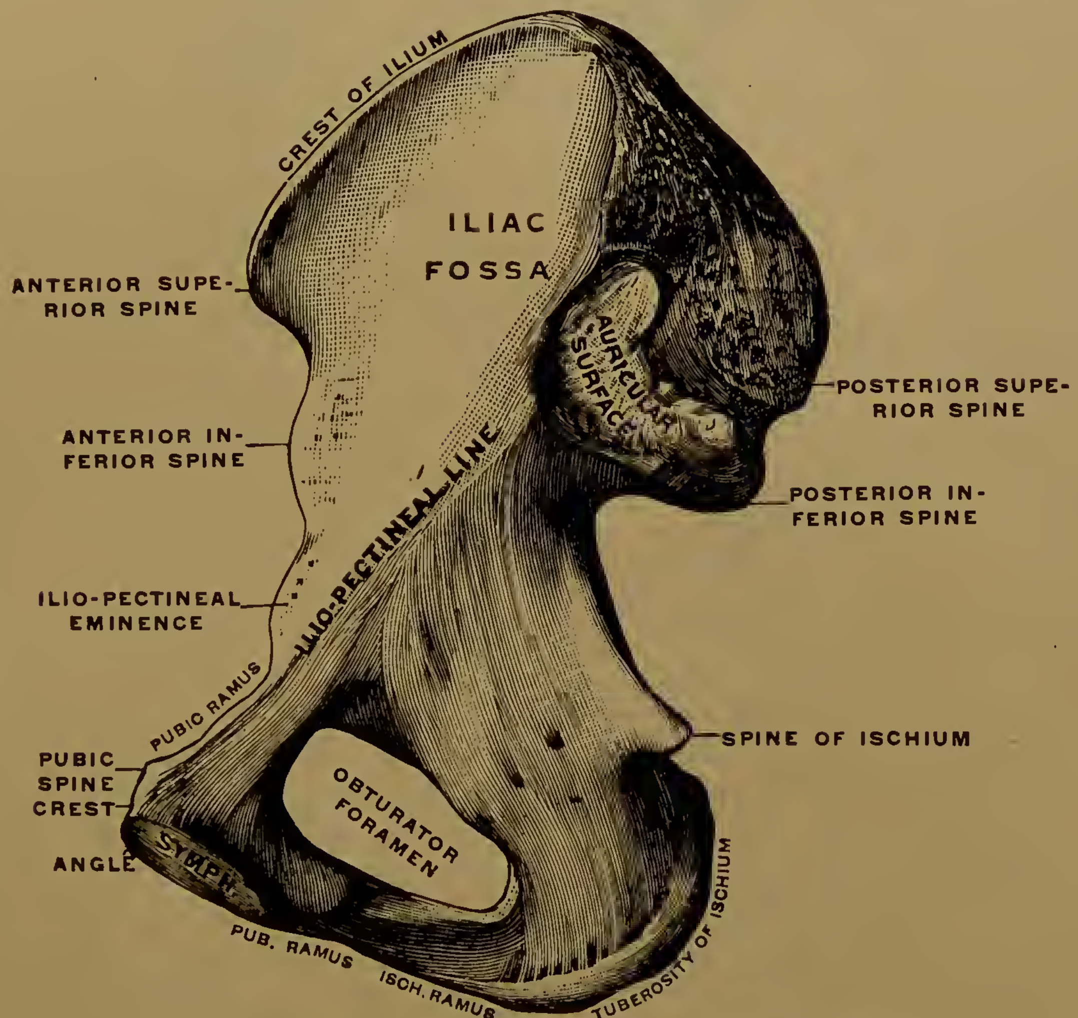


FIG. 179.—The right hip-bone, inner surface. (Testut.)

which the obturator internus tendon glides, separates the spine from the tuberosity below. The *tuberosity* presents dorsally a rough quadrate surface, from the upper and outer portion of which the semi-membranosus arises, and from the lower and inner part the semi-tendinosus and biceps. This area is separated by a transverse ridge from a pyriform, rough surface in front of it, which is continuous with the lower and inner border of the ramus and gives origin to the adductor magnus. The sharp inner lip of the tuberosity affords attachment to the falciform prolongation of the great sacro-sciatic ligament, and from the outer lip the quadratus femoris arises. The *ramus*, flattened like the descending ramus of the os pubis, with which it is continuous, presents a thin upper margin bounding the obturator foramen, and a thicker, everted, lower margin for ligamentous and muscular attachment. From its outer surface the obturator externus and adductor magnus arise, and from its inner surface arise the obturator internus, constrictor urethræ, crus penis, and erector penis, and, dorsally, the transversus perinei.

The Os Pubis.

The *ossa pubis* ("bones of the pubes") form the front wall of the pelvis. Each consists of a flat, quadrate body, situated internally and joined with the ilium and ischium, respectively, by two rami, the horizontal and descending. The *ventral surface of the body and of the descending ramus* is rough for the origin of muscles. The corresponding dorsal or *pelvic surface* is smooth. From the ventral surface arise the obturator externus, the gracilis, and the three adductors; from the dorsal surface arise the obturator internus and levator ani.

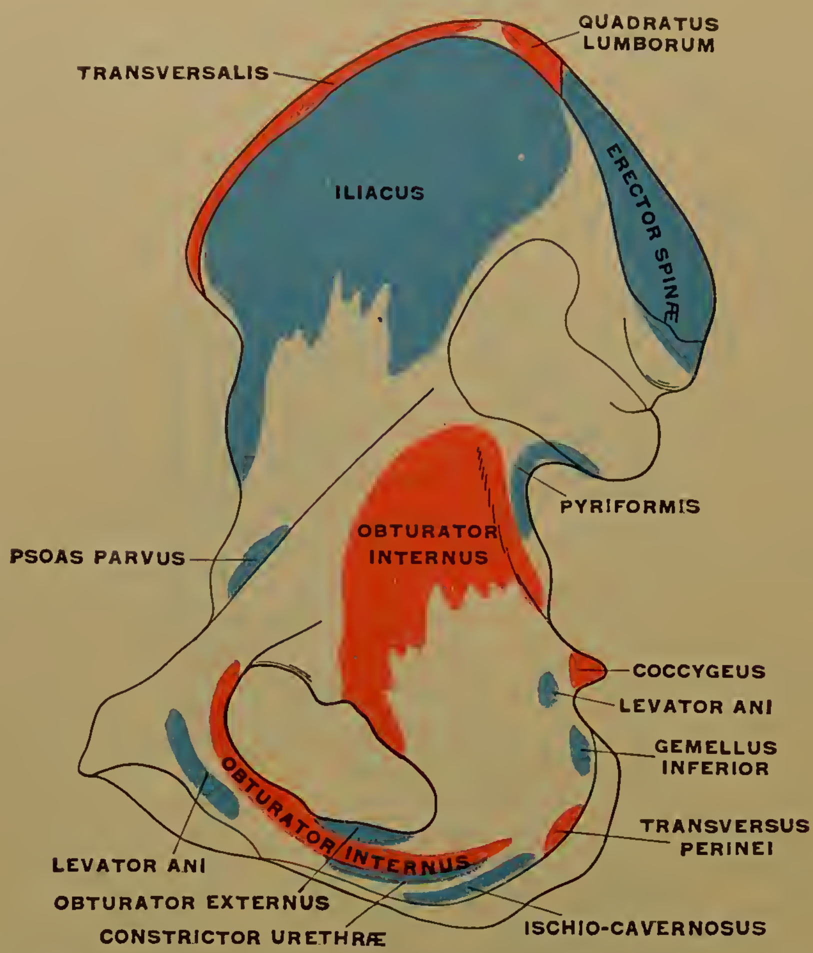


FIG. 180.—Areas of muscular attachment, inner surface of right hip-bone. (Testut.)

The *inner border of the combined pubic and ischiatic rami* of the two sides, which form the pubic arch, is rough and more or less everted, especially in the female. The *outer border of the body and descending ramus* is narrow, and bounds the obturator foramen. The *inner border of the pubic body* presents an elongated, oval surface which is joined by cartilage to the opposite bone, forming the *symphysis pubis.* The broad, rough *upper border* of the body or *pubic crest* stretches from the upper end of the symphysis, *the angle,* outward to the prominent *spine of the os pubis.* To the crest are attached the rectus abdominis and pyramidalis and the conjoined tendon; to the spine, the inguinal (Poupart's) ligament. The *horizontal ramus* extends from the body to the ilium at the iliopectineal eminence, and expands at its outer end to form the ventral fifth of the acetabulum. It is more or less triangular on section, and its *upper border* is the pubic portion of the *ilio-pectineal line,* to which Gimbernat's ligament and a part of the conjoined tendon are attached internally. The triangular surface in front of this line gives origin to the pectineus, and is bounded below by the prominent *obturator crest,* which extends from the pubic spine to the cotyloid notch. The under surface bounds the obturator foramen superiorly, and presents externally the deep oblique *obturator groove* for the obturator vessels and nerve.

The *acetabulum* ("small cup"), or *cotyloid cavity,* is a nearly hemispherical cavity which looks outward, downward, and forward. It consists of a horse-

shoe-shaped marginal articular portion, which articulates with the femoral head, and a depressed central and inferior non-articular portion, which lodges a mass of fat. The upper part of the margin is the stoutest and most prominent; the lower part is deficient close to the obturator foramen, forming the *cotyloid notch*, which is bridged across by the transverse ligament, forming the *cotyloid foramen* for the passage of a nerve and vessels into the joint and to the head of the femur. To the margin of the articular portion the cotyloid ligament is attached, deepening the cavity so that it is more than a hemisphere, and outside of this the capsular ligament arises.

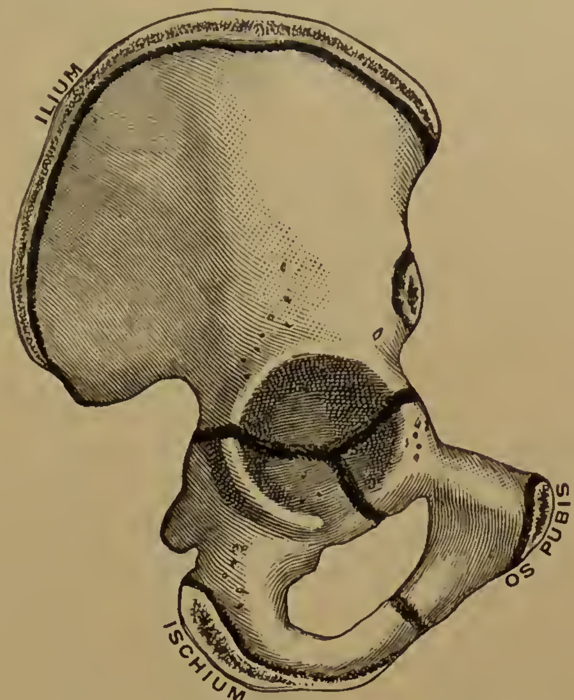


Fig. 181.—Development of the hip-bone, showing the union of the three portions in the acetabulum. (Testut.)

The *obturator* or *thyroid foramen*, below and internal to the acetabulum, is formed by and situated between the ischium and os pubis. It is closed by the fibrous obturator membrane, which is attached to its margins except near the groove for the obturator vessels and nerve, in its upper margin. In the female it is broad and triangular, in the male oval and elongated downward and backward.

The iliac crest, pubic spine, tuberosity of the ischium, and combined rami of the os pubis and ischium (bounding the perineum) can be felt subcutaneously. The anterior superior iliac spine and the pubic spine are of great importance as landmarks. The hip-bone is much thickened along the lines of greatest pressure —*i. e.*, between the auricular surface and the upper part of the acetabulum and the tuberosity of the ischium. There is a thick ridge running from the acetabulum to the iliac crest, but the centre of the iliac fossa as well as of the acetabulum is thin.

Ossification (Fig. 181) takes place in cartilage from a centre for each of the three parts, ilium, ischium, and os pubis. A secondary centre appears later in the Y-shaped cartilage, where they meet in the acetabulum. This fuses with and joins together the three parts from the sixteenth to the twentieth year. Secondary nuclei appear for the iliac crest, the anterior inferior spine, the ischial tuberosity, and the pubic crest from the fifteenth year on, and unite with the main bone about the twentieth year.

THE PELVIS.

The pelvis (Figs. 182, 183), whose constituent parts, the two hip-bones, connected behind by the sacrum and coccyx, have already been described, is divided into two parts by a plane passing through the sacral promontory behind, the ilio-pectineal lines laterally, and the pubic crests in front. The part above this plane, composed of the ilia, belongs to the abdominal cavity, but is called the *false pelvis*. The limiting line is called the *brim*, and the included heart-shaped space the *inlet* of the lower part, or *true pelvis*. The *outlet*, or lower circumference of the pelvic cavity, presents three prominences—the ischial tuberosities laterally and the coccyx behind—separated by three notches, the pubic arch in front and the two sciatic notches behind. The *pubic arch* is the angular space in front beneath the symphysis and bounded by the combined rami of the ischia and ossa pubis. The sciatic notches are bridged across and converted into foramina by the sacro-sciatic ligaments, which bound the outlet of the pelvis as well as the perineum dorso-laterally.

The *cavity* of the pelvis is shallow ($1\frac{1}{2}$–2 inches) in front, where it is bounded by the os pubis, and deepest (5–$5\frac{1}{2}$ inches) behind, where the curved sacrum and coccyx form its bony wall. The ischia form the lateral walls. The *axis* of the

pelvis, or the line drawn through the centres of the planes of the inlet, cavity, and outlet of the pelvis, is curved with its concavity forward.

The *position of the pelvis* in the erect attitude of the body is so tilted or inclined that the plane of the inlet forms an angle of 50° to 60° with the horizon, so that a line drawn at right angles to the centre of the plane of the inlet,

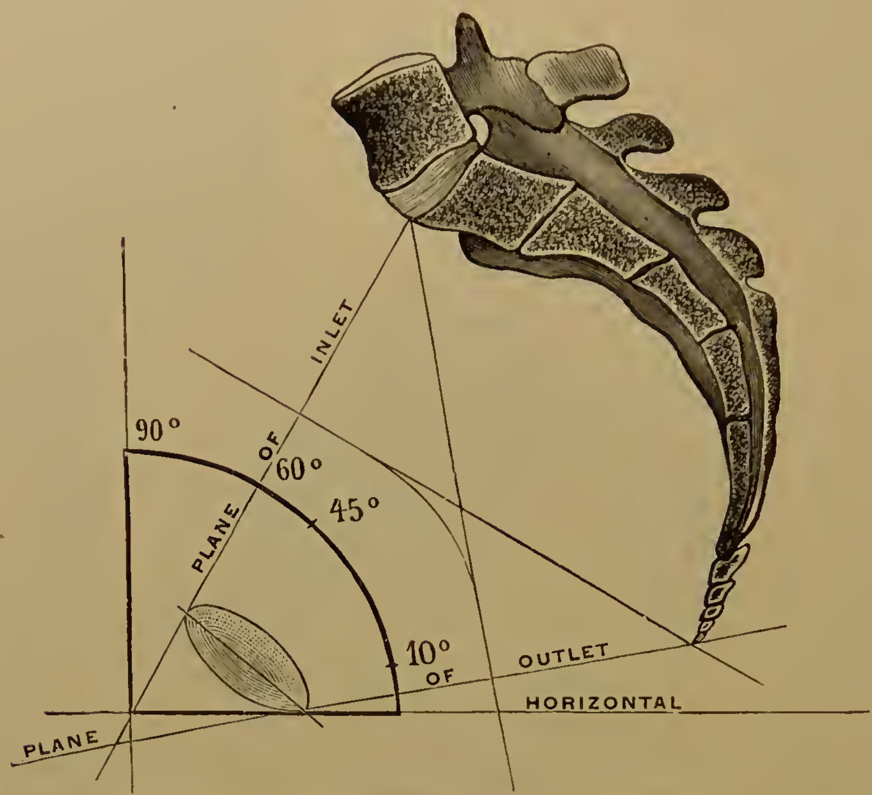


FIG. 182.—The planes of the pelvis. (Testut.)

if prolonged upward, would about meet the umbilicus. Furthermore, the base of the sacrum is raised about $3\frac{1}{2}$ inches above the upper margin of the symphysis pubis, and the tip of the coccyx is $\frac{1}{2}$–1 inch above the lower end of the symphysis. The plane of the outlet is more nearly horizontal, forming an angle of about 15° with the horizon.

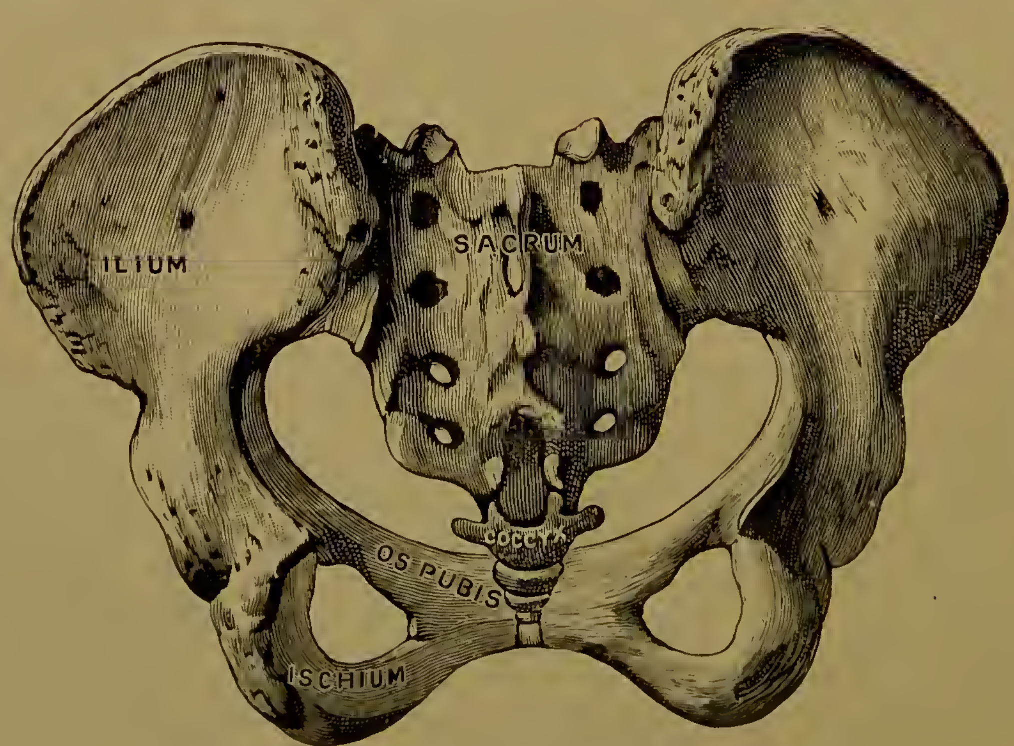


FIG. 183.—The female pelvis, rear view. (Testut.)

This tilting of the pelvis brings the sacrum more or less on top, where, however, it does not form the keystone of the arch, for its widest aspect looks downward into the pelvis; and the bone is held in place mainly by the strong posterior sacro-iliac ligaments, and only slightly by the projection of the lower and ventral margins of the auricular surfaces of the ilium. The weight of the body is transmitted from the sacro-iliac joint in an arch along the massive ilio-pectineal line to the acetabulum in the standing posi-

tion, and to the ischial tuberosities in the sitting posture. The horizontal rami of the ossa pubis form the counter-arches or ties to the former arch, the combined ischial and pubic rami to the latter arch. The pressure along the arches and counter-arches when the bones are softened by rickets or osteomalacia causes various deformities of the pelvis. The pelvis is admirably adapted for a variety of functions. To receive and transmit the weight of the body to the lower extremities in standing, and to the ischial tuberosities in sitting, it is provided with very strong ridges of bone between the very secure sacro-iliac articulations and the acetabula and ischial tuberosities. To prevent these arched ridges from collapsing from pressure, they are connected together anteriorly by the counter-arches, which meet at the symphysis. In this way a rather shallow cavity is formed, which contains and protects the pelvic viscera, and is so shaped as to allow of the passage of the fœtal head in parturition. The flaring ilia also help to support the abdominal viscera, and the wide expanse of bone presents a large surface for muscular attachment under conditions favorable for leverage.

Sex differences relate to both size and form. In the female the bones are lighter and smoother. The cavity is broader, more capacious, and less deep. The symphysis is not so deep, the pubic arch wider, the ischial tuberosities more expanded, and the sacrum flatter and broader. The sacral promontory is less projecting, giving the pelvic inlet a more oval shape. The thyroid foramina are more triangular. The differences of sex are noticeable in early life; but in general all pelves are more or less of the male type until about puberty, when the female characteristics become marked.

The following table represents the average measurements of the pelvis in inches:

Diameters.	Male.			Female.		
	Brim.	Cavity.	Outlet.	Brim.	Cavity.	Outlet.
Greatest transverse	5	$4\frac{3}{4}$	$3\frac{1}{2}$	$5\frac{1}{4}$	5	$4\frac{3}{4}$
Conjugate or ventro-dorsal	4	$4\frac{1}{4}$	$3\frac{1}{4}$	$4\frac{1}{2}$	5	$4\frac{1}{2}$
Oblique (from the sacro-iliac joint to the ilio-pectineal eminence)	$4\frac{3}{4}$	$4\frac{1}{4}$	4	5	$5\frac{1}{4}$	$4\frac{1}{2}$

THE FEMUR.

The *femur* (Figs. 184, 186), the largest and longest bone in the body, is inclined inward and slightly backward, so as to approach its fellow inferiorly. It extends between and articulates with the hip-bone above and the tibia below.

The *upper extremity* includes the head, the neck, and the two trochanters, which give attachment to the rotator muscles. The *neck* extends inward, upward, and slightly forward from the shaft to the head. It is compressed from before backward, but expanded vertically, especially where it joins the shaft. Its length is greater behind and below, and it is concave behind. Its axis forms an angle of 125° with that of the shaft. At birth this angle averages 160°. During growth, owing to the weight of the body, it decreases to from 140° to 110°; but after growth is completed, it remains fixed. It is less in females and short subjects. The *head* is received into the acetabulum of the hip-bone. It forms more than half a sphere, and is covered with cartilage, except at a small pit behind and below the centre, to the upper half of which the ligamentum teres is attached. At the junction of the neck and shaft the two trochanters project. The *great trochanter* is a stout, quadrilateral plate, continuous with the outer surface of the shaft, which reaches nearly to the highest level of the neck. On its outer surface the gluteus medius is attached to an oblique line extending downward and forward from its dorso-superior angle. The lower limit of this surface and the upper extent of the vastus externus are marked by a horizontal line, which, in front of the trochanter, turns upward to an eminence, the *tubercle*, at the junction of the trochanter with the neck anteriorly. Internal to the trochanter and between it

and the neck is the deep *digital* or *trochanteric fossa*, which receives the tendon of the obturator externus. Above and in front of this fossa the obturator internus and the gemelli are inserted. Behind the latter the pyriformis is inserted on the narrow free *upper border*. The gluteus minimus is inserted upon the *anterior border*, while the thick, rounded *posterior border* is continuous with the *posterior intertrochanteric line*, which runs downward and inward to the small trochanter

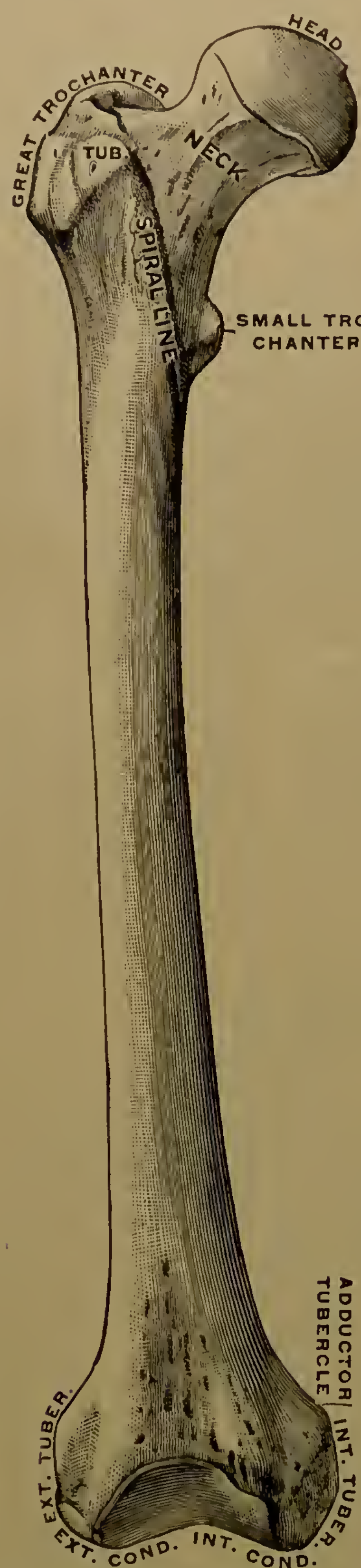


FIG. 184.—The right femur, front view. (Testut.)

FIG. 185.—Areas of muscular attachment, ventral surface of right femur. (Testut.)

and limits the neck behind. The *small trochanter*, receiving the insertion of the ilio-psoas, projects as a pyramidal eminence from the dorso-internal aspect, where the lower end of the neck joins the shaft. The *anterior intertrochanteric line* limits the neck in front, and gives attachment to the thickened front part of the capsular ligament. It is the upper part of the *spiral line*, above the small trochanter. The spiral line runs from the tubercle of the femur downward and inward to the linea aspera, passing a little in front of the small trochanter.

The *shaft*, arched convexly forward, is nearly cylindrical, except for a flattening in front and a prominent buttress-ridge, the linea aspera ("rough line") behind; so that three rather indistinct surfaces, a ventral and two lateral, may be distinguished, which are covered by the three vasti muscles. The shaft expands as it approaches the lower extremity. The *linea aspera* presents in the central third two lips and a rough, narrow interval, often called the middle lip. In the upper

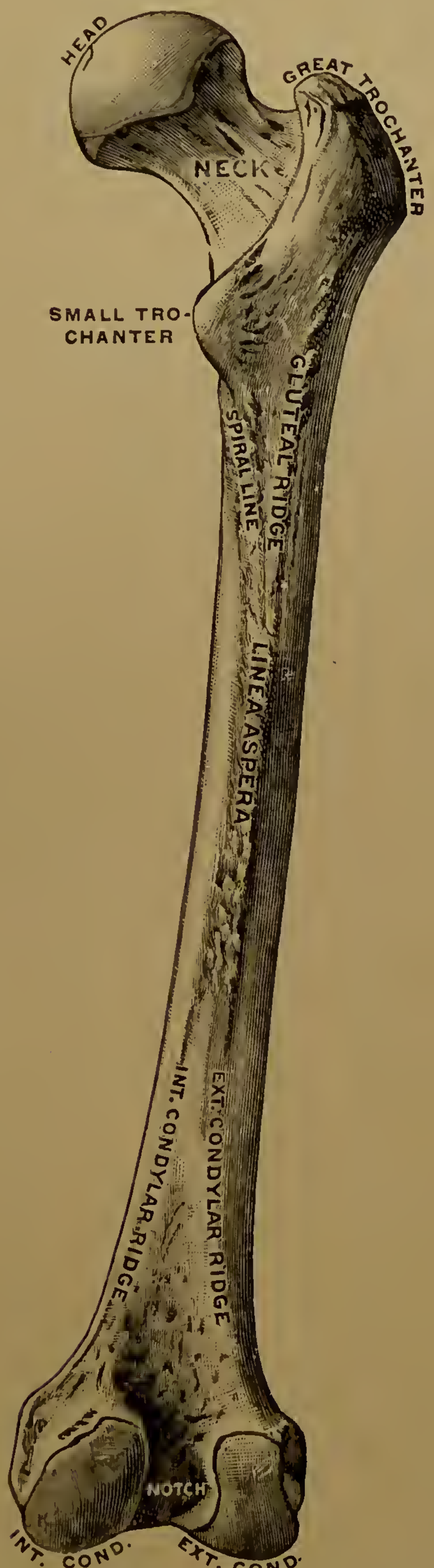


FIG. 186.—The right femur, rear view. (Testut.)

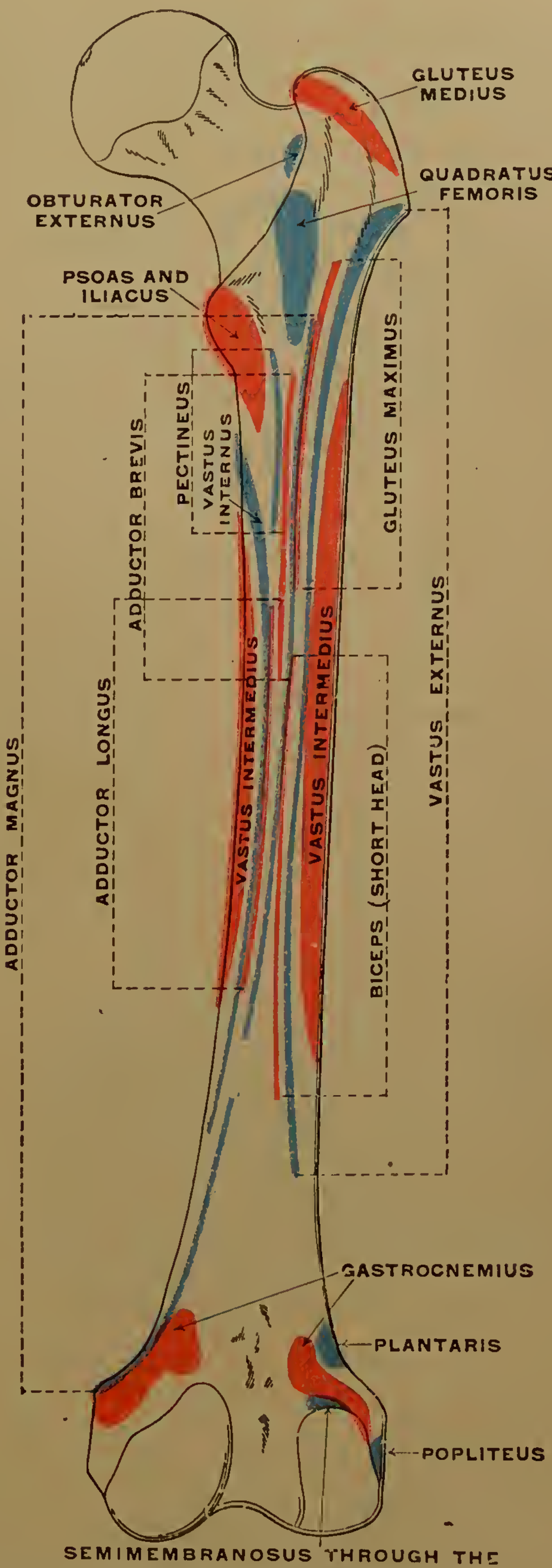


FIG. 187.—Areas of muscular attachment, dorsal aspect of right femur. (Testut.)

third the external lip extends up to the great trochanter as the prominent *gluteal ridge* for the gluteus maximus. The internal lip is continuous with the spiral line, while a third line, giving insertion to the pectineus, ascends to the small trochanter from the intermediate space. Inferiorly the two lips diverge, and extend to the condyles as the *external* and *internal condylar ridges*, enclosing a flat triangular area, the floor of the upper part of the popliteal space. The inner ridge is interrupted in the upper part by the crossing of the femoral vessels,

and ends below in the sharp *adductor tubercle*, to which the lowest fibres of the adductor magnus are attached. The *canal of the nutrient artery* is directed upward in the linea aspera a little above its centre. The following muscles, besides those already mentioned are attached to the linea aspera and its prolongations: To the inner lip is attached the vastus internus, and to its lower two-thirds the adductor longus; to the outer lip the vastus externus; and to its lower two-thirds and the external condylar ridge the short head of the biceps. The adductor magnus is inserted below into the inner condylar ridge and the adductor tubercle, in the middle third to the intermediate space, and superiorly just internal to the gluteal ridge, as far as the quadratus femoris. The adductor brevis is attached to the upper third of the intermediate space below and external to the pectineus. A faint line, the *linea quadrati*, for insertion of the quadratus femoris, is sometimes visible, and passes upward from the outer side of the small trochanter to the middle of the posterior intertrochanteric line, where the *tubercle of the quadratus* is sometimes seen. Part of the iliacus is attached to an area below the small trochanter, internal to the pectineus.

The *lower extremity* presents *two condyles*, external and internal, most prominent behind, where they are separated by the deep *intercondylar notch*, while in front they are united by the *trochlear* (articular) *surface* for the patella. The part of the trochlea external to its vertical groove is the larger, and is very prominent along its outer edge, serving to resist the tendency to outward dislocation of the patella. Continuous with the trochlea are the cartilage-clad lower and dorsal surfaces of the condyles, which, though of different curvatures in different parts, articulate with the tibia. The external condyle is the broader, the internal the narrower and the more prominent laterally and behind, while in front it bends outward to the patellar surface. In the natural or inclined position of the bone the lower surfaces of the two condyles are in the same plane; but, if the bone is held vertically, the inner is the lower. On the lateral surface of each condyle the corresponding lateral ligament of the knee-joint is attached to a rough *tuberosity*. Below the outer tuberosity the popliteus arises from a depression, from which a groove passing backward and slightly upward is occupied by the tendon of the muscle in flexion of the knee. To the mesial surfaces bounding the intercondylar notch the crucial ligaments are attached, the anterior to the external condyle behind, the posterior to the internal condyle in front. Immediately above the condyles on the posterior surface the two heads of the gastrocnemius muscle arise, and above its outer head is the origin of the plantaris.

The great trochanter, the two condyles, and, during flexion, the trochlear surface for the patella, are the only subcutaneous parts of the bone. The great trochanter is an important landmark.

The femur averages 18 inches in length in the European male, and 17 inches in the female. It is inclined inward at an angle of about 9° with the sagittal plane in the male, and at a greater angle in the female. The femur presents an angle of torsion between its upper and lower extremities, ranging between 5° and 20°, but in the opposite direction to that of the humerus. The lamellæ of the cancellous tissue at the upper extremity, which spring from the upper end of the shaft and the lower side of the neck internally, and the upper end of the shaft externally, radiate inward to the head and outward to the great trochanter. They thus cross one another in arches which strengthen the neck of the bone, through which the weight of the body is transmitted from the head to the shaft. A nearly vertical plate of compact bone (*calcar femorale*, "femoral spur") projects into the interior, toward the great trochanter, from a little in front of the small trochanter, and strengthens the concave side of the neck. It is liable to absorption in old age. The depression for the ligamentum teres is wanting in a small proportion of cases, and in a still smaller number is replaced by a tubercle. The gluteal ridge is sometimes so prominent as to be called the *third trochanter*.

Ossification occurs in the shaft from one centre, which appears very early. The lower epiphysis appears as a single centre. One after another centres appear

for the head and the great and small trochanters. These join the shaft as follows: small trochanter, seventeenth year; great trochanter, eighteenth year; head, nineteenth year; condyles, twentieth to twenty-first year. The neck is an outgrowth from the shaft. The line of fusion of the condylar epiphysis with the shaft is below the adductor tubercle and the origins of the gastrocnemius muscle.

THE PATELLA.

The *patella* ("little dish"), or *knee-pan* (Figs. 188, 189), is a flattened, triangular sesamoid bone in the quadriceps extensor tendon at the front of the knee-joint.

FIG. 188.—The right patella, ventral surface. (Testut.)

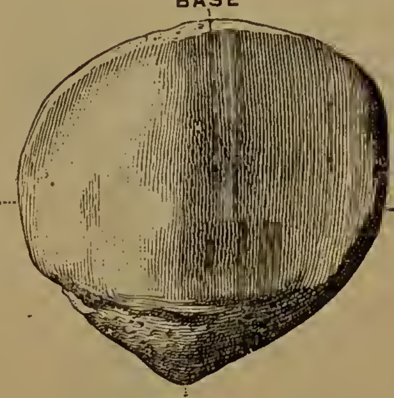


FIG. 189.—The right patella, dorsal surface. (Testut.)

Its slightly convex *ventral surface* is longitudinally grooved by the fibrous expansion of the tendon. Its *dorsal surface* is mostly cartilage-clad, to articulate with the trochlear surface of the femur, and is divided by a vertical ridge into a large outer, concave portion and a smaller inner, convex one, to articulate with the outer and inner sides, respectively, of the trochlear surface. The *upper border*, or base, is bevelled in front, and gives insertion to the tendons of the muscles composing the quadriceps extensor. The *apex*, directed downward, and the border on either side of it give attachment to the ligamentum patellæ, while the narrow, rough, non-articular area of the dorsal surface above the apex is in relation to a mass of fat. In front of the patella is a bursa separating it from the skin. The entire articular surface is not in contact with the femur at any time, but one part after another as the knee is moved.

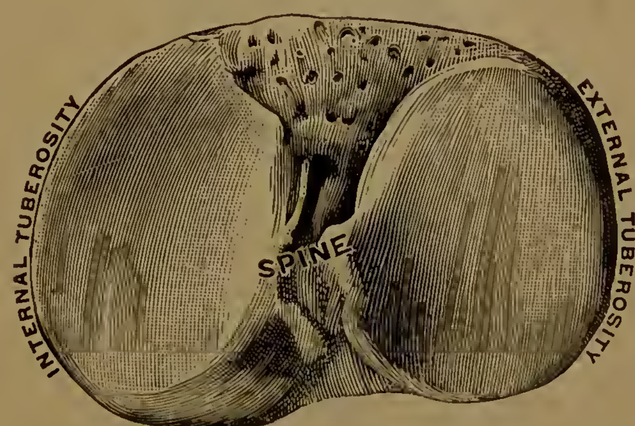


FIG. 190.—The upper surface of the right tibia. (Testut.)

The patella is liable to transverse fracture from muscular action, and, as its blood-supply comes largely from above, care should be taken in dealing with the upper fragment not to strangulate it.

THE TIBIA.

The *tibia* ("shin") (Figs. 190–194) is the inner, larger, and more anterior of the bones of the leg, and conveys the weight of the body from the femur to the astragalus.

The *upper extremity*, or *head*, is thick and inclined slightly backward above. It is expanded on each side into a massive *tuberosity*, whose upper aspect presents a slightly concave articular surface, which receives one of the condyles of the femur. Of these *articular surfaces*, the inner is longer from before backward and more concave; the outer is smaller, flatter, and more circular. Both are flattened peripherally, where the semilunar fibro-cartilages rest upon them and deepen the socket for the femoral condyles. Projecting upward, between these surfaces, is

the *spine* of the tibia, which is laterally bifid. To rough depressions between the articular surfaces are attached in front of the spine the anterior crucial ligament and the anterior extremities of the semilunar cartilages, and behind the spine the posterior crucial ligament and the posterior extremities of the semilunar cartilages. The depression behind the spine is continued backward into a notch, the *popliteal notch*, which separates the tuberosities posteriorly. In front the tuberosities are continuous, and form on the anterior surface of the head a triangular area, whose apex points downward and ends at the *tubercle*. The lower end of the latter gives attachment to the ligamentum patellæ; its upper smooth part is

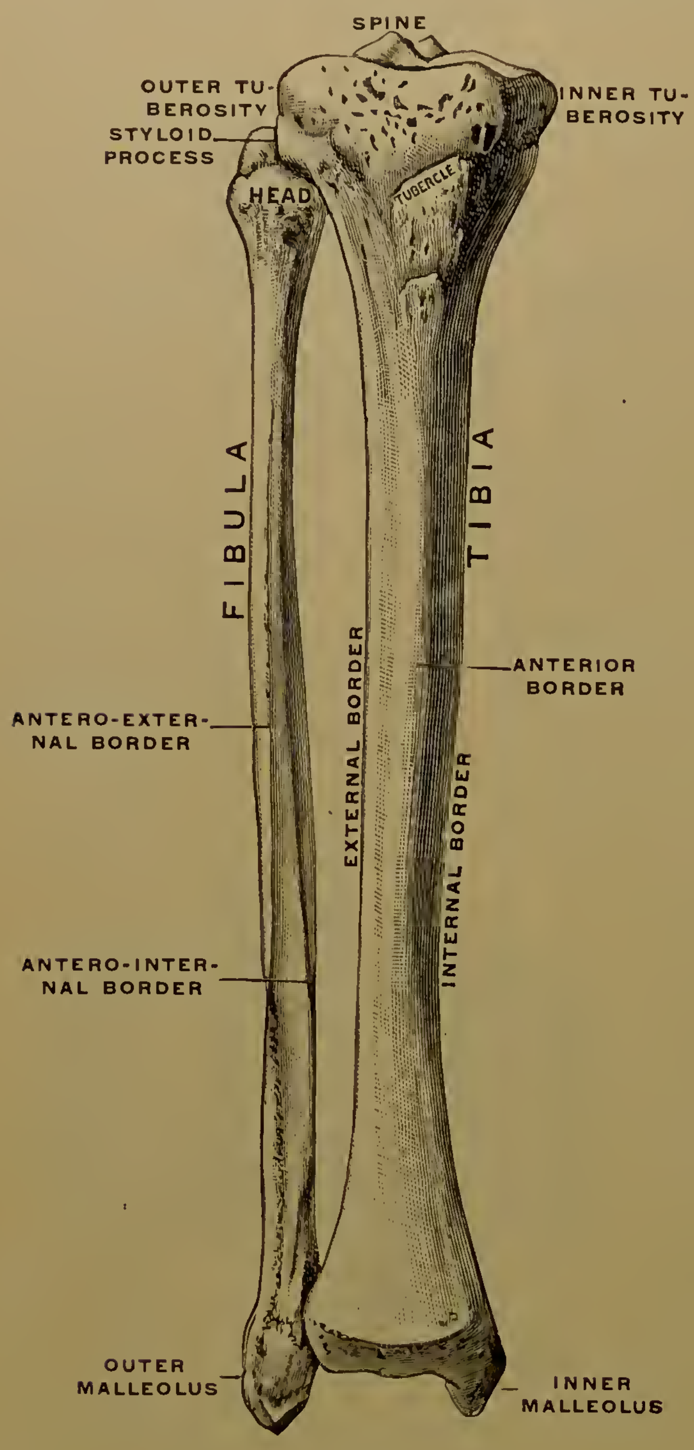


FIG. 191.—The right tibia and fibula in their normal relations, front view. (Modified from Testut.)

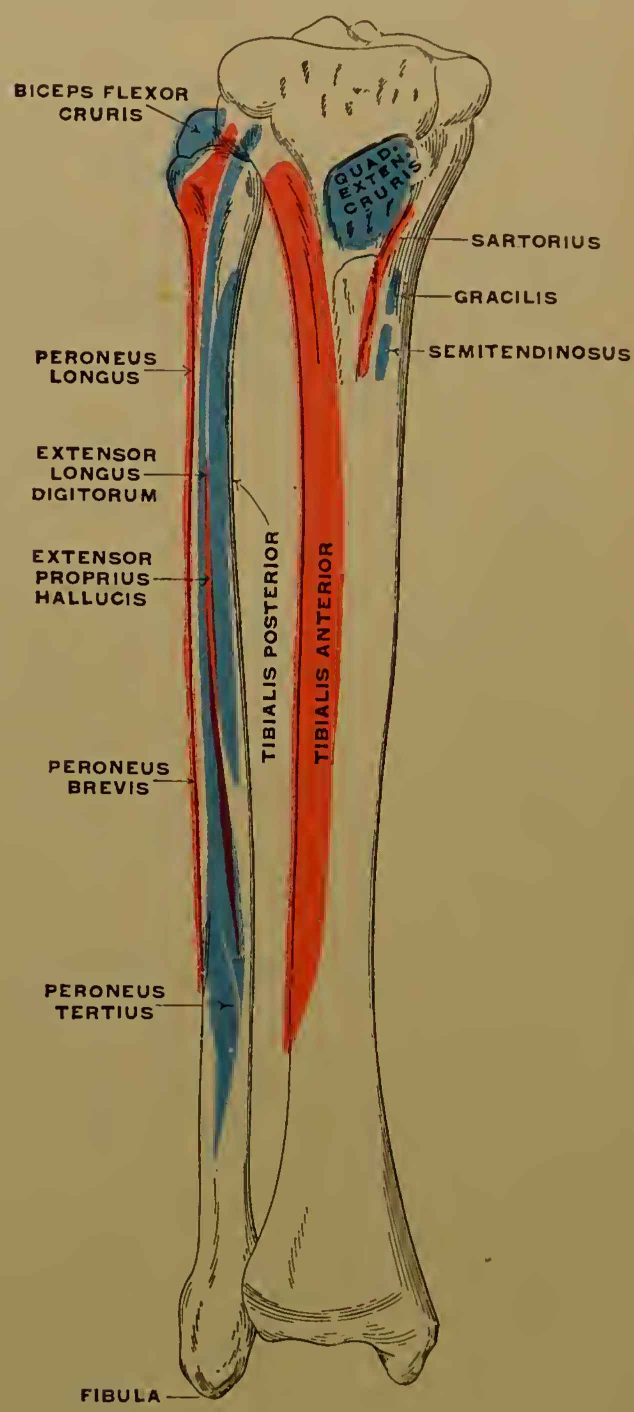


FIG. 192.—Areas of muscular attachment, anterior aspect of the tibia and fibula.

separated from the ligament by a bursa. Upon the tubercle the body rests in kneeling. At the outer angle of this triangular surface is a prominence to which the ilio-tibial band of the fascia lata is attached. The larger, internal tuberosity is marked behind by a horizontal groove for the insertion of the semi-membranosus tendon, and the external tuberosity presents postero-externally a rounded *articular facet* for the head of the fibula.

The three-sided *shaft* of the tibia is very thick above and tapers toward the lower third, where it again expands slightly. The *internal surface* is convex and subcutaneous, except at the upper end, where, internal to the tubercle, the sar-

torius, gracilis, and semi-tendinosus tendons are attached in the order named from above downward. The *external surface* is concave in its upper two-thirds, where it gives origin to the tibialis anterior, convex below, where it looks more forward and is covered by the extensor tendons. On the *posterior surface* the popliteus is inserted on a triangular area at the upper end, limited below by the *oblique line*, which passes from the fibular facet downward and inward to the internal border, and gives attachment to the soleus muscle. Below the oblique line this surface is

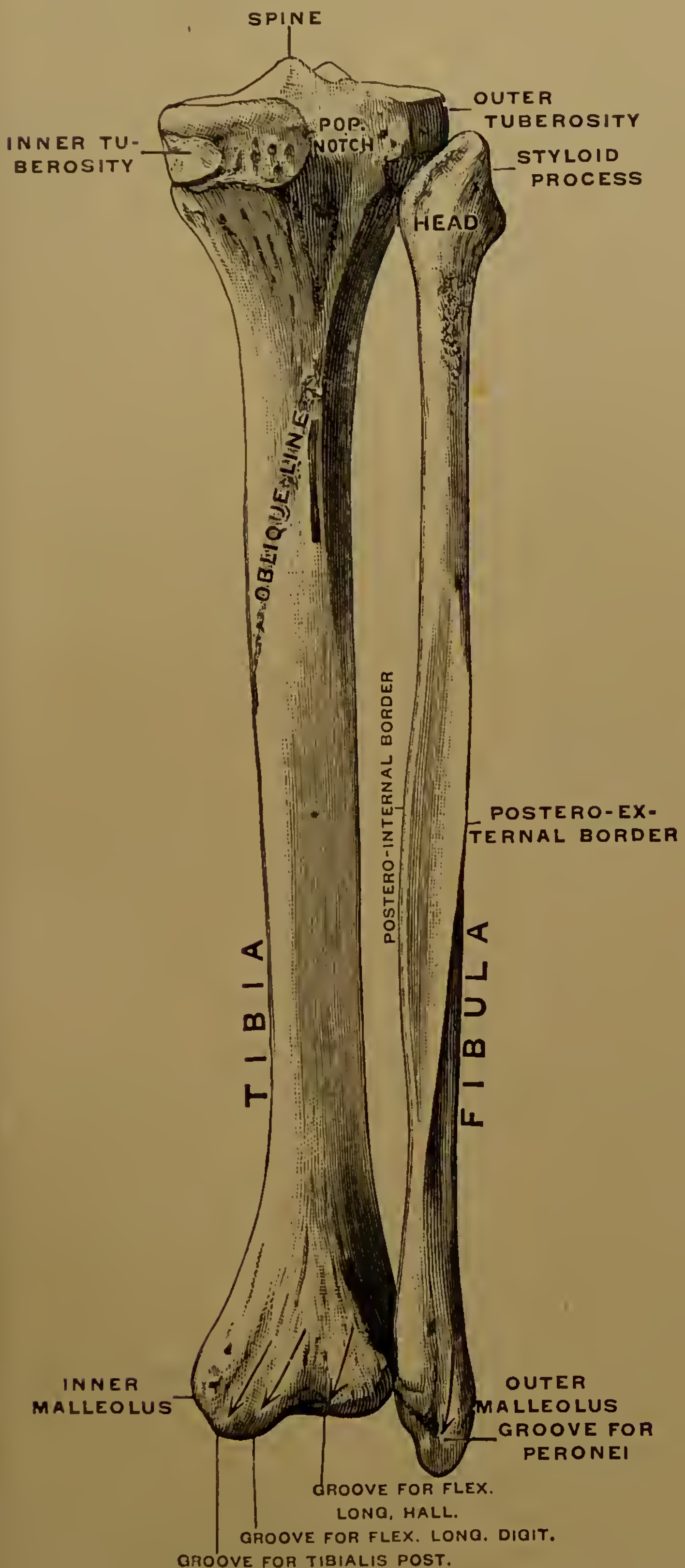


FIG. 193.—The right tibia and fibula in their normal relations, rear view. (Testut.)

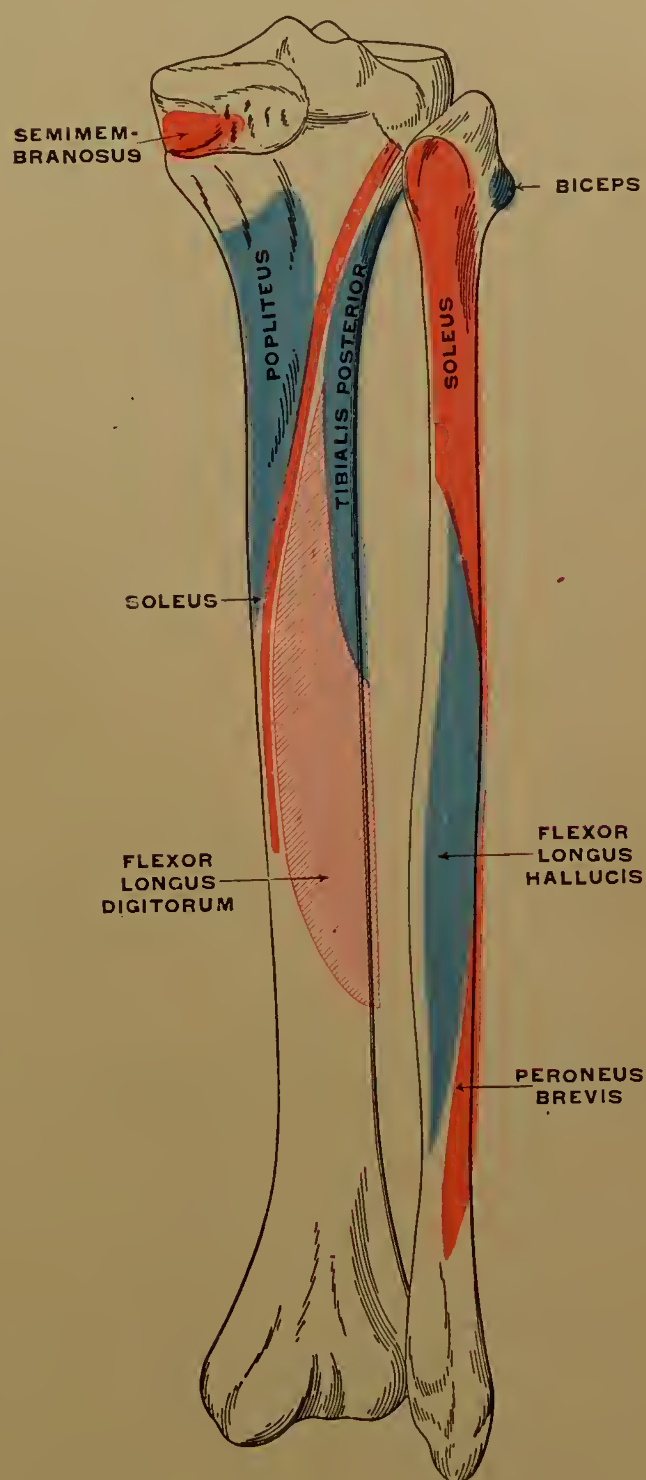


FIG. 194.—Areas of muscular attachment, posterior aspect of the tibia and fibula.

divided by a longitudinal ridge into an inner portion giving origin to the flexor longus digitorum, and an outer portion, from which arises the tibialis posterior. At the upper part of this surface and below the oblique line is found the large *foramen for the nutrient artery*, directed downward. The *anterior border*, or *shin*, commencing above, just below the tubercle, is subcutaneous, sinuous, and sharp in its upper two-thirds, rounded in its lower third, where it passes to the front of the internal malleolus. The *external* or *interosseus border* gives attachment to the interosseous membrane and bifurcates near the lower end, thus enclosing a trian-

gular area for the inferior interosseous ligament. The *internal border* extends from the back of the internal tuberosity above to the back of the internal malleolus below. The internal lateral ligament is attached to its upper 3 inches, the soleus muscle to its middle third.

The *lower extremity* is somewhat quadrilateral, and is expanded transversely. It is prolonged downward, internally, as a flattish, subcutaneous process, the *internal malleolus*, from the tip and margins of which the internal lateral ligament of the ankle arises. The fore part of its external surface is articular, for the inner lateral facet of the astragalus, and is continuous with its inferior quadrilateral articular surface, which articulates with the upper surface of the astragalus. This inferior facet is concave from before backward, and is narrower, and descends lower behind than in front. Behind the malleolus is a groove for the tibialis posterior and the flexor longus digitorum, while farther externally the flexor longus hallucis slightly grooves the posterior border. The external surface of the lower extremity of the bone presents at its lower end a narrow articular area, which articulates with the fibula. This area is continuous with the inferior articular surface, and above it the outer surface is rough for ligaments which attach it to the fibula.

The tibia is twisted, so that when the axis of the upper end is transverse that of the lower end is inclined from without inward and forward at an angle averaging 5°–20°, but sometimes varying between 0° and 48°.

Ossification.—Each epiphysis ossifies from a single centre. That in the upper end includes the tubercle and appears first. The lower end unites with the shaft at the eighteenth or nineteenth year, the upper end in the twenty-first or twenty-second year.

THE FIBULA.

The *fibula* ("clasp" or "brace") (Figs. 191, 193) is the slender outer bone of the leg. Its Greek name is *perone,* the adjective from which ("peroneal") is synonymous with "fibular." It reaches lower than, but not as high as, the tibia. Its upper end is behind the plane of the lower end, and its shaft is slightly curved and very variable in its contour.

The *upper extremity* or *head* is irregularly expanded, and presents above and internally a small obliquely placed articular facet, looking upward, inward, and forward, articulating with the facet on the outer tuberosity of the tibia. Behind and slightly external to the facet rises a conical eminence, the *styloid process,* to which the short external lateral ligament of the knee is attached, while to a slight depression in front of and external to it are attached the external lateral ligament and the tendon of the biceps.

The *lower extremity* is a thick pyramidal process which forms the *external malleolus* ("little hammer"). The latter is lower and more posterior than the internal malleolus. Its *inner surface* presents in front a triangular facet for articulation with the outer facet on the astragalus, above which the cartilage-clad surface is continued upward for a quarter of an inch for articulation with the tibia. Above the articular surface is a rough triangular area for the inferior interosseous ligament. Behind the facet is a rough depression for the attachment and reception of the posterior fasciculus of the external lateral ligament of the ankle. The *posterior surface* is grooved for the tendons of the peronei longus and brevis. The *external surface* is subcutaneous and continuous with a subcutaneous triangular surface tapering upward for two or three inches upon the shaft.

The *shaft* has four variable surfaces, each giving origin to a muscle or a group of muscles which produce a particular motion of the foot. The four borders limiting these surfaces give attachment to fibrous septa separating the muscles or muscle-groups. The lower fourth of the shaft is twisted outward. The well-marked *antero-external border* begins in front of the head, and bifurcates in the

lower fourth to include the triangular subcutaneous surface above mentioned as being continuous with the outer surface of the malleolus. To it is attached the anterior tibial fascia which separates the peronei longus and brevis, which pronate the foot and occupy the *external* or *pronator surface*, from the extensores longus digitorum and proprius hallucis and the peroneus tertius, which arise from the narrow *anterior* or *flexor surface*, and flex the ankle on continuing their primary action. The *external surface* twists backward in the lower fourth to become continuous with the posterior surface of the malleolus. The *antero-internal* or *interosseous border* (Fig. 195) is close to the antero-external border above, but diverges from it below, where, an inch or more above the malleolus, it ends at the apex of the rough triangular area, which gives attachment to the inferior interosseous ligament. This border affords attachment to the interosseous membrane, which separates the muscles arising from the anterior surface from the tibialis posterior, which supinates the ankle and arises from the fusiform *internal* or *supinator surface*. The latter surface occupies the upper two-thirds only of the shaft. It is separated from the posterior surface by the *postero-internal border*, which joins the interosseous border in the lower third, and gives attachment in the upper two-thirds to a fibrous septum, the *deep transverse fascia*, separating the muscles which arise from the surfaces on either side. The *posterior* or *extensor surface*, becoming more internal below, gives origin to the soleus above and the flexor longus hallucis below. The latter muscles are separated from the peronei by a septum

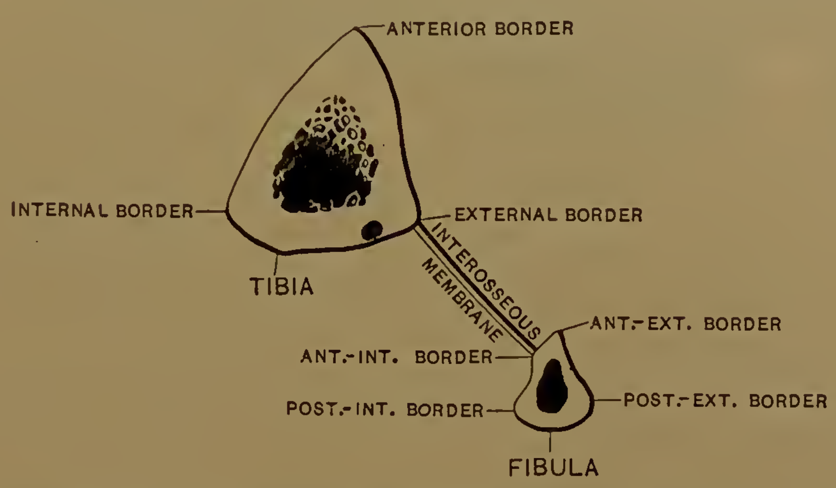


FIG. 195.—Horizontal section of the bones of the leg at the junction of the upper and middle thirds, showing their borders and surfaces and the relations of the interosseous membrane. (Testut.)

attached to the prominent *postero-external border*. This border passes from the styloid process to the back of the malleolus. The *nutrient foramen*, directed downward, is seen in the middle third of the posterior surface.

The head, the outer surface of the malleolus, and the triangular area above it are subcutaneous; otherwise the shaft is covered by muscles. When fracture occurs, it is very commonly an inch or two above the malleolus.

Ossification.—The lower epiphysis, although it ossifies first, joins the shaft about the twentieth or twenty-first year, while the upper epiphysis remains separate until the twenty-second to the twenty-fourth year. The human fibula is vestigial, especially its upper end, which accounts for the fact that this end not only ossifies last, but also unites with the shaft last.

THE BONES OF THE FOOT.

The skeleton of the foot is composed of three groups of bones—those of the *tarsus* ("the flat of the foot"), *metatarsus* ("beyond the tarsus"), and *digits*. The bones of the foot, although resembling those of the hand, are modified in the direction of greater firmness, and are in a position of permanent pronation and dorsal flexion.

THE TARSAL BONES.

The *tarsus* contains seven bones—the astragalus, calcaneum, cuboid, scaphoid or navicular, and the three cuneiform bones.

The Astragalus.

The *astragalus* ("a die"), or *talus* (Figs. 196, 198, 202, 203), occupies the upper part of the arch of the foot, where it articulates with the tibia above and internally, and with the fibula externally. It receives the weight of the body from the tibia, and transmits it by articulation to the calcaneum below and the scaphoid in front. Its long axis is directed forward and inward to the convex anterior extremity, or *head*, which is joined by a slightly constricted *neck* to the main part, or *body*, behind. The *upper surface* is occupied by the trochlear articular surface for the tibia. This is convex from before backward, and slightly concave transversely. It is broader in front than behind, and continuous with the lateral facets for the malleoli. The facet on the *outer surface*, for the external malleolus, is triangular and vertically concave; that on the *inner surface*, for the internal malleolus, is smaller, narrow, and pyriform. To the rough surface below the internal facet is attached the deep portion of the deltoid ligament. The *under surface* presents a deep groove for the interosseous ligament, which passes from within obliquely outward and forward to the neck, and separates the two facets which articulate with the calcaneum. The posterior facet is concave from behind forward; the anterior is convex and rests upon the facet on the sustentaculum tali of the os calcis. The anterior facet is continuous in front with the oval facet on the head, for the scaphoid, though there intervenes between them internally a small facet which rests upon the inferior calcaneo-scaphoid ligament. The *posterior surface* is a mere narrow border, grooved internally for the flexor longus hallucis. The *tubercle* bounding this groove externally gives attachment to the posterior band of the external lateral ligament of the ankle, and is sometimes found as a separate bone, the *os trigonum* ("triangular bone").

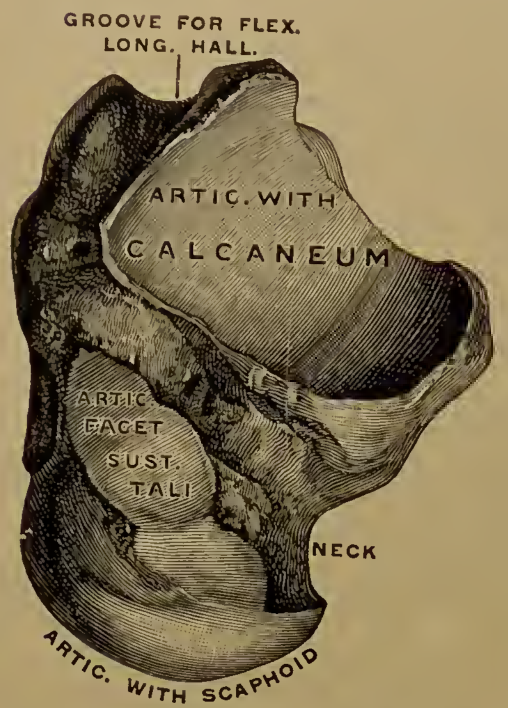


FIG. 196.—Right astragalus, under surface. (Spalteholz.)

The Calcaneum.

The *calcaneum* ("heel") or *os calcis* (Figs. 197–202), the largest bone of the foot, projects backward and downward to form the heel, which acts as a fulcrum for the calf-muscles. It transmits most of the weight of the body to the ground. Its long axis is directed forward and a little outward from its enlarged posterior extremity.

The *upper surface* presents in its fore part two facets for articulation with the astragalus. The larger, posterior, and external facet is convex from before backward; the anterior one is long, concave and often subdivided. It is located on the upper surface of the *sustentaculum tali* ("support of the astragalus"), a flat, shelf-like process projecting inward on a level with the upper surface. Between these two facets is a groove for the interosseous ligament, passing obliquely forward and outward to a rough area on the fore part of the upper surface, where the extensor brevis digitorum arises. The *under surface* is narrow, rough, and transversely convex. It ends behind in two tubercles, which give attachment to plantar muscles and the plantar fascia. The inner tubercle is the larger, the outer the

more prominent. In front of these the long plantar ligament is attached, while the short plantar ligament is attached to the anterior tubercle at the fore end of this surface and to the shallow groove in front of it. The *inner surface* is concave between the posterior surface behind and the sustentaculum tali in front. The under surface of the latter presents a groove continuous with that at the back of the astragalus for the flexor longus hallucis tendon. The *outer surface*, rough, flat, and subcutaneous, presents at its fore part two slight grooves, the upper for the tendon of the peroneus brevis, the lower for that of the peroneus longus, separated by a ridge or tubercle, the *peroneal spine*. The *posterior surface* is smooth above, where it is separated by a bursa from the tendo calcaneus (Achillis), which

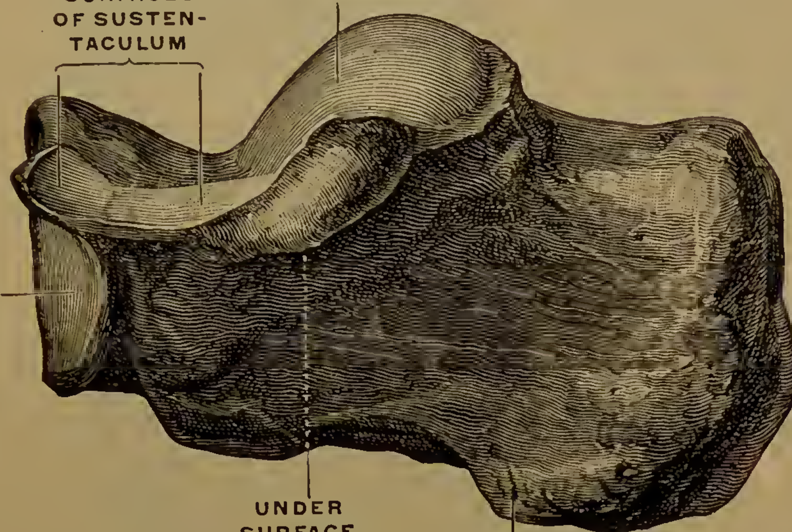


FIG. 197.—Right calcaneum, internal surface. (Spalteholz.)

is attached to the lower part of this surface. On the *anterior surface* is a saddle-shaped articular facet for the cuboid.

The calcaneum and astragalus are both very vascular. The veins of the former emerge mostly on the inner side, where they are less exposed to pressure.

The Cuboid.

The *cuboid* ("cube-like") (Figs. 198–202) lies on the outer side of the foot, between the calcaneum behind and the fourth and fifth metatarsals in front. Although cuboidal, the four surfaces adjoining the external converge to it, giving the bone a pyramidal shape. *Posteriorly*, it articulates with the calcaneum by a saddle-shaped facet prolonged backward at the lower and internal angle, beneath the calcaneum. *Anteriorly*, a smaller facet is divided into an outer triangular and an inner quadrilateral portion for the fifth and fourth metatarsal bones, respectively. The *upper surface*, directed somewhat outward, is flat and non-articular. The *lower surface* presents a prominent ridge or *tuberosity*, directed obliquely inward and forward, in front of which is a deep groove for the peroneus longus. To the ridge and the triangular surface behind it are attached the plantar ligaments. On the narrow *external surface* or border the outer end of the ridge on the lower surface projects as a tubercle, which is usually facetted for a sesamoid bone in the bend of the peroneus longus tendon. The *internal surface* presents near its middle and upper part a facet for the external cuneiform, and oftentimes behind this a second facet for the scaphoid, while the rest of the surface is rough for interosseous ligaments.

The Scaphoid.

The *scaphoid* or *navicular* ("boat-shaped") *bone* (Figs. 198–203), situated on the inner side of the foot between the astragalus and the cuneiform bones, is com-

pressed from before backward. Proximally its concavity articulates with the head of the astragalus. Its convex *distal surface* is subdivided into three triangular facets for the cuneiform bones. *Above* it is rough and convex, *below* more narrow and uneven, *externally* rough for ligaments, with an inconstant facet for

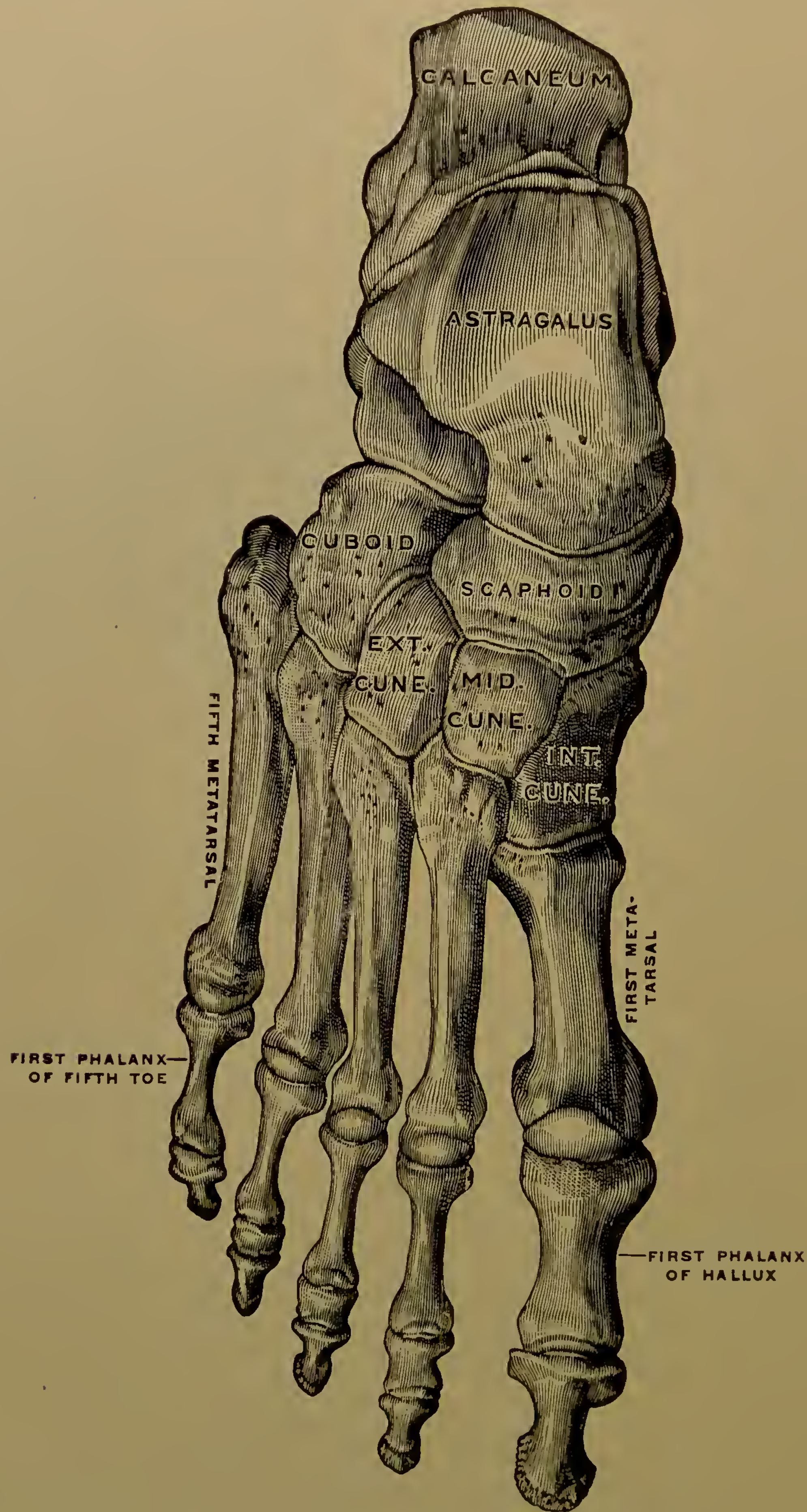


FIG. 198.—The bones of the right foot, viewed from above. (Albinus.)

the cuboid. *Internally* it is prolonged downward and inward into the prominent *scaphoid tuberosity*, which gives insertion to part of the tibialis posterior, and, being subcutaneous, is an important landmark in finding the medio-tarsal (Chopart's) joint, which is bounded behind by the astragalus and calcaneum, in front by the scaphoid and cuboid.

The Cuneiform.

The *three cuneiform bones,* named respectively from their position from within outward, *internal, middle,* and *external,* are wedge-shaped, and lie between the scaphoid and the three inner metatarsal bones. Their proximal surfaces, articu-

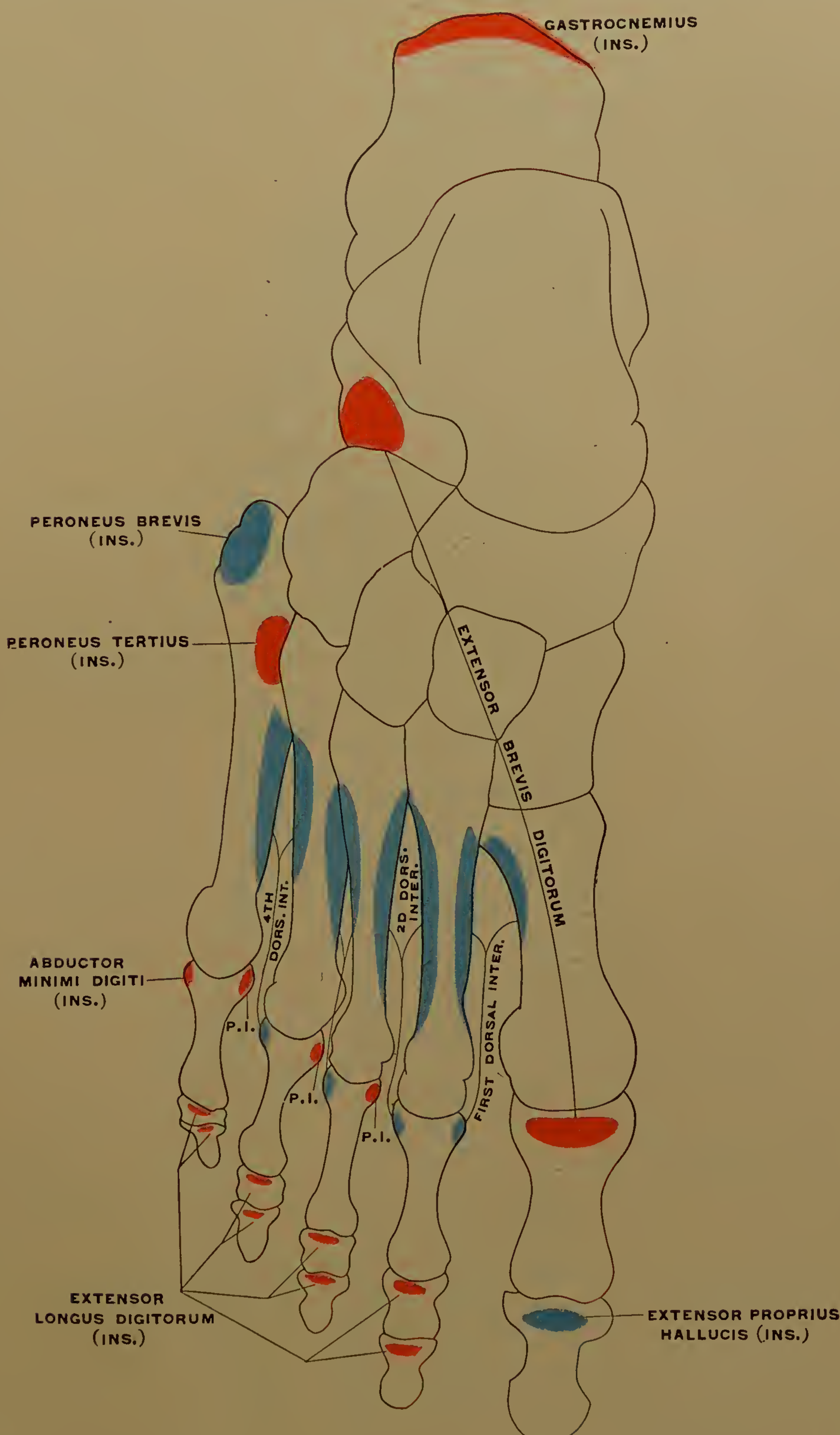


FIG. 199.—Areas of muscular attachment on the dorsal surface of the bones of the foot. Where the areas of origin and insertion are both presented, they are in the same color. The third dorsal interosseous is not labelled. P.I.=plantar interosseous insertion. INS.=insertion.

lating with the scaphoid, are concave and in the same transverse line; their distal surfaces, articulating with the three inner metatarsals, are convex or flat, and the middle cuneiform being the shortest, a deep recess is formed, into which the base of the second metatarsal is received.

The Internal Cuneiform.

The *internal cuneiform* (Figs. 198, 200, 203), the largest of the three, has the base of the wedge directed downward on the inner border of the foot. The distal, kidney-shaped facet for the base of the first metatarsal is much larger than the proximal pyriform facet for the scaphoid. On the internal surface is an oblique shallow groove for the tibialis anterior tendon, leading to an oval facet antero-inferiorly where the tendon is in part attached. On the rough, concave external surface there is an L-shaped facet along the upper and posterior borders, which articulates with the middle cuneiform, and in front, where a distinct facet is marked off, with the inner side of the base of the second metatarsal bone.

The Middle Cuneiform.

The *middle cuneiform* (Figs. 198–202), the smallest of the three, has its base directed upward. The facets in front and behind are wedge-shaped, that in front for the second metatarsal being slightly smaller. On the inner surface is an L-shaped facet along its upper and posterior borders corresponding to and articulating with that on the internal cuneiform. On the outer surface a facet along its posterior border articulates with the external cuneiform.

The External Cuneiform.

The *external cuneiform* (Figs. 198–202) also has its base directed upward. Continuous with the triangular facet for the base of the third metatarsal are small facets at the fore part of each lateral surface, internally for the second metatarsal and externally for the fourth metatarsal. The internal surface has in addition a facet along its posterior border for the middle cuneiform, and the external surface has a larger facet behind and above for the cuboid.

The Metatarsal Bones.

The five *metatarsal bones* (Figs. 198–203) are numbered from within outward. They closely resemble the metacarpal bones in having irregular cuboidal bases, articulating with the same number of bones as do the metacarpal; in having tapering triangular shafts, slightly concave from end to end on the plantar aspect; and in having laterally compressed heads with articular facets extending onto the plantar surfaces, where they are grooved for the flexor tendons, and with lateral tubercles and depressions for the lateral ligaments. The line of their bases slopes from within outward and backward, and is interrupted by the mortising of the second between the internal and external cuneiform bones.

The *first metatarsal*, the stoutest and shortest, has on its *base* a large, slightly concave, kidney-shaped facet for the internal cuneiform, and an inconstant facet externally for the second metatarsal. The lower part of the base projects downward and slightly outward as the *tuberosity*, which gives insertion to part of the peroneus longus externally and of the tibialis anterior internally. On the plantar surface of the large *head* are two deep grooves for the sesamoid bones.

The *second metatarsal* is the longest; the others diminish in length to the fifth. The base of the second articulates in the mortise with the three cuneiform bones, and externally by two facets with the third metatarsal, and occasionally internally with the first metatarsal.

The *base* of the *third metatarsal* articulates proximally with the external cuneiform, internally by two facets with the second metarsal, and externally by a single facet with the fourth metarsal.

The *base* of the *fourth metatarsal* articulates proximally with the cuboid, internally with the third metatarsal by a single facet, and usually with the external cuneiform. Externally there is a single facet for the fifth metarsal, bordered by a deep groove for ligaments.

The *base* of the *fifth metatarsal* articulates proximally with the cuboid, internally with the fourth metatarsal. On its outer aspect it projects as a large rough *tuberosity* upon which the tendon of the peroneus brevis is inserted. Being subcutaneous, it is an important landmark on the outer border of the foot.

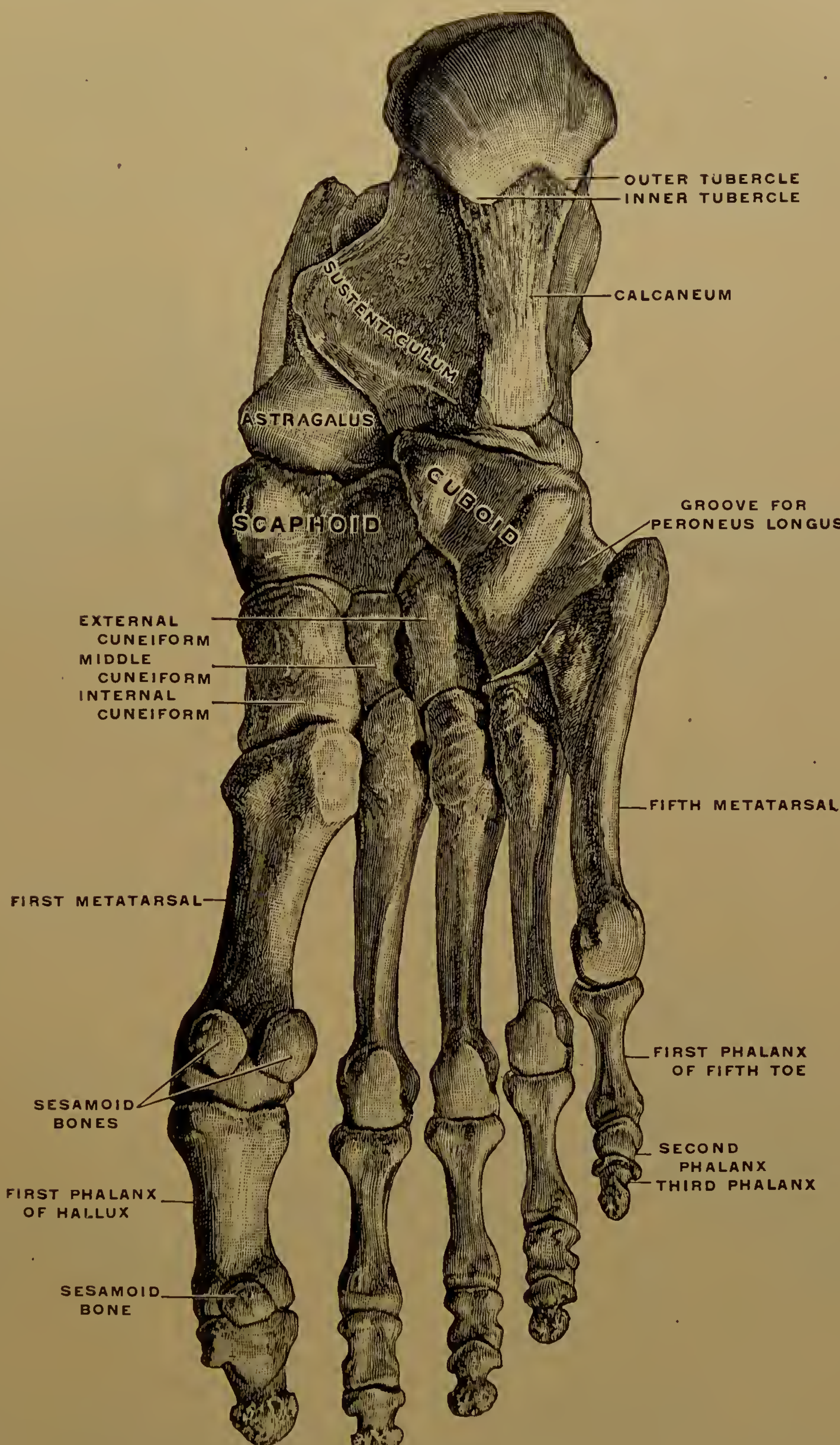


FIG. 200.—The bones of the right foot, viewed from below. (Spalteholz.)

THE PHALANGES.

The *phalanges* (Figs. 199–204) resemble so closely those of the fingers that only the differences need be noticed. Those of the great toe are larger than those of the thumb, while those of the other toes are much smaller than those of the

corresponding fingers. The shafts of the phalanges of the *first row*, in the four smaller toes, are narrowed in the middle, being compressed laterally. In the same toes the phalanges of the *second row* are very short and stunted, especially

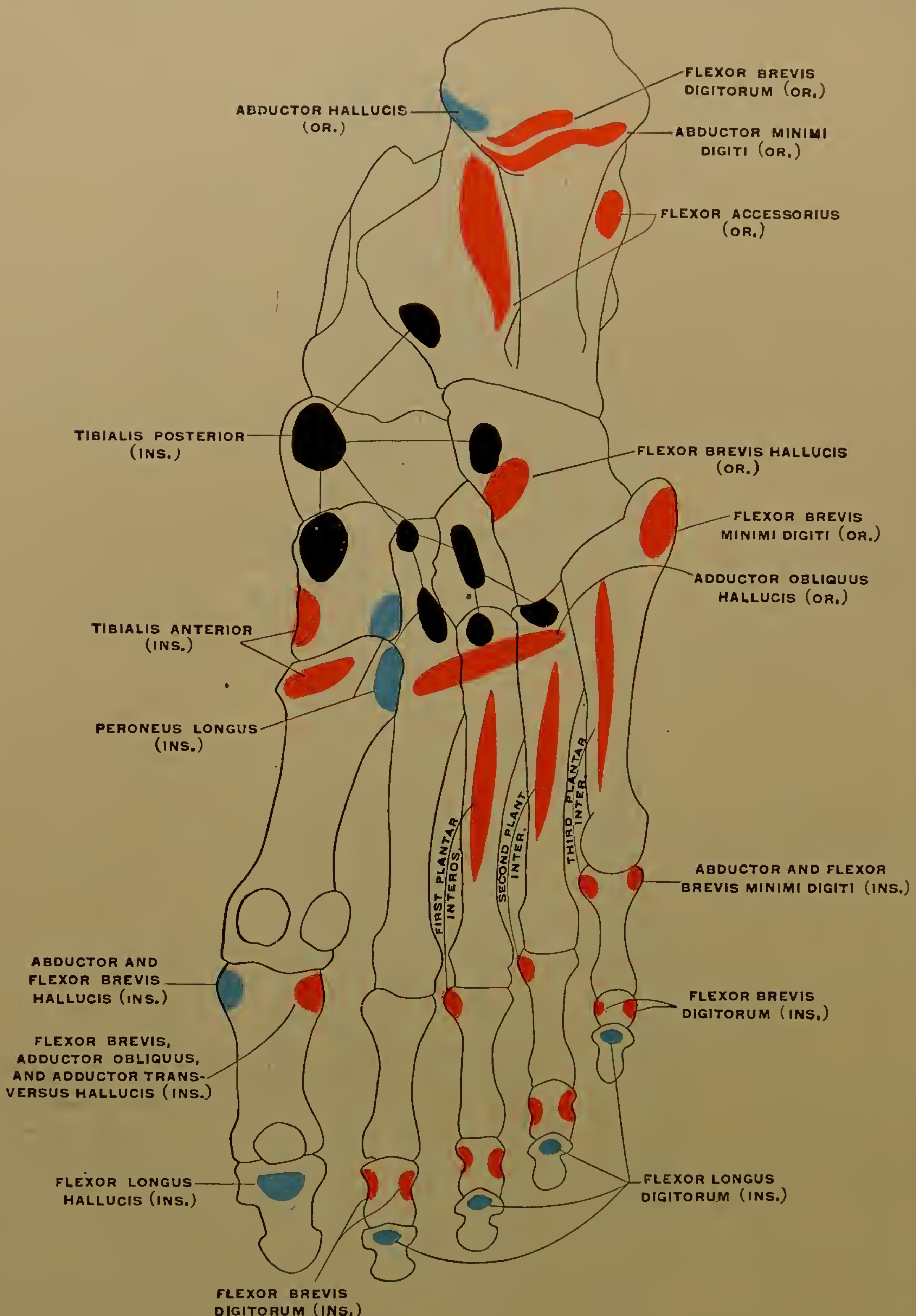


Fig. 201.—Areas of muscular attachment on the plantar surface of the bones of the foot. Where the areas of origin and insertion are both presented, they are in the same color. OR. = origin. INS. = insertion. The insertion of the second and third tendons of the flexor brevis digitorum are not labelled.

those of the fourth and fifth toes, which are not infrequently ankylosed with the terminal phalanges.

The two *sesamoid bones* in the tendon of the flexor brevis hallucis glide in the two grooves on the plantar aspect of the head of the first metatarsal bone. Sesamoid bones occasionally occur elsewhere in the foot.

Ossification.—The metatarsal and phalangeal bones ossify exactly like the orresponding bones in the hand.

THE FOOT AS A WHOLE (Figs. 199–204).

The foot is narrowest at the heel and widens to the heads of the metatarsal ones. The bones of the foot form a *longitudinal arch* with a single pier, the calaneum, behind, while the forward pier is formed by the heads of the metatarl bones. It may be divided longitudinally into two parts in front, with a comon support behind. The inner division consists of the posterior two-thirds of e calcaneum and the astragalus, scaphoid, cuneiforms, and the three inner meta-

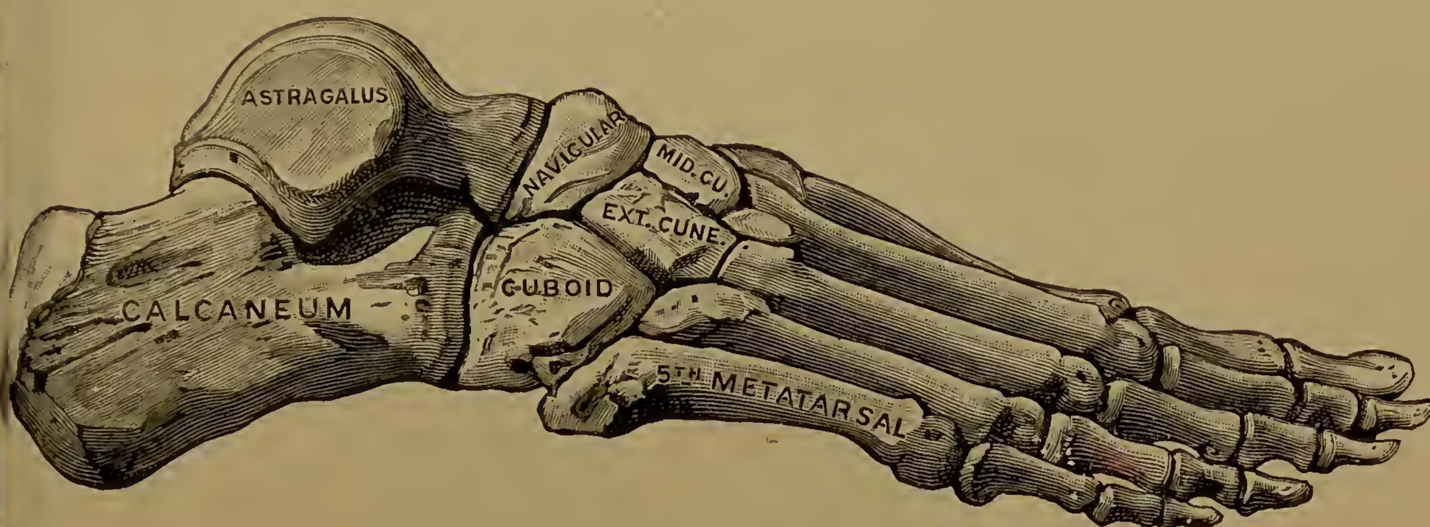


FIG. 202.—The bones of the right foot, viewed from the outer side. (Testut.)

arsals. It bears the greater part of the weight, and is more raised from the round and more springy than the outer arch. The outer division is formed by he calcaneum, bearing the cuboid and the two outer metatarsals, and acts mainly s a buttress to the inner arch. The longitudinal arch is supported largely by he plantar ligaments. The *transverse arch*, having its two internal piers at the nternal cuneiform and the first metatarsal, and its external piers at the cuboid

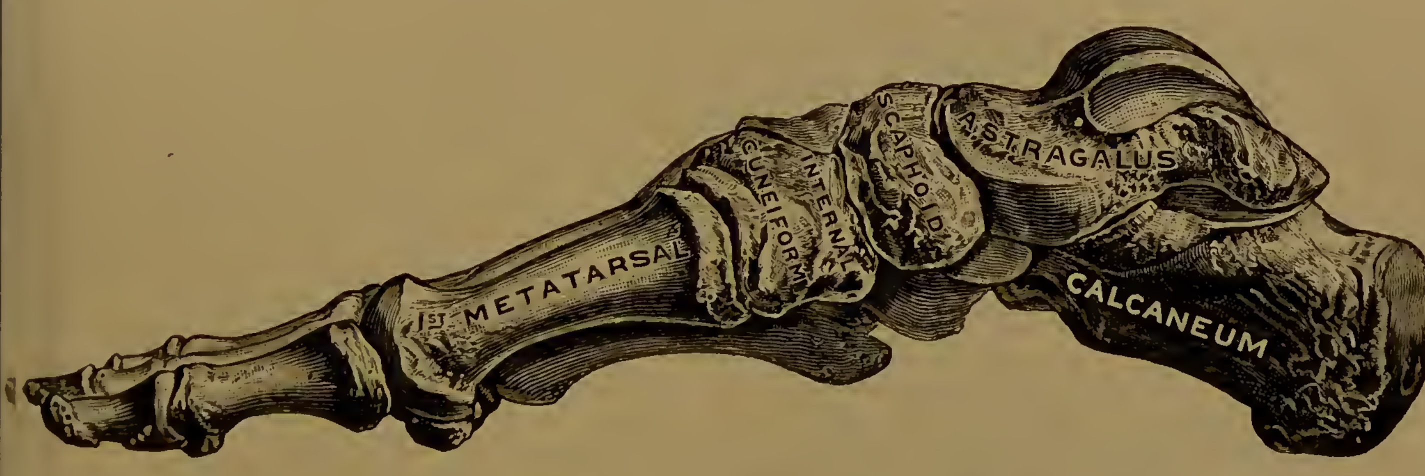


FIG. 203.—The bones of the right foot, viewed from the inner side. (Spalteholz.)

nd the fifth metatarsal, is formed by the wedge-shape of the cuneiform bones nd of the bases of the metatarsals.

The longitudinal arch is weakest between the astragalus and scaphoid, where t is liable to yield, giving rise to flat-foot. In this condition it is well seen that he arch is not quite straight from the heel to the toes, but is slightly convex nternally and concave on the outer border. The astragalus inclining inward nd the calcaneum outward in front, the outer border of the upper surface of the ormer is found over the middle of the latter. This makes the internal malleolus ppear more prominent, for the external malleolus lies over the outwardly pro-

jecting calcaneum. In infancy the head of the astragalus is inclined inward more than in the adult, and the foot is then naturally inverted.

The tuberosity of the scaphoid on the inner border of the foot and that of the base of the fifth metatarsal on the outer border, both readily felt through the soft parts, are the best guides to the medio-tarsal and tarso-metatarsal joints, respectively. The tuberosity of the fifth metatarsal is a finger's breadth in front of the medio-tarsal joint, and directly in front of the tarso-metatarsal joint; that of the scaphoid is two fingers' breadth behind the tarso-metatarsal and directly in front of the medio-tarsal joint.

Homologies of the Bones of the Two Extremities.

The following conclusions are generally admitted: The thoracic and pelvic limbs are constructed on the same type in their attaching girdles and their several segments. In the pelvic and shoulder girdles the ilium corresponds to the scapula and the ischium to the coracoid process.

At an early stage of embryonic life the limbs are folded ventrally upon the body, and present pre- and post-axial borders. The dorsal or extensor surfaces are external and the ventral or flexor surfaces are internal. Later, the upper limb rotates outward 45°, and the lower limb rotates inward 90°. This brings the flexor surface in the upper limb forward and inward, and in the lower limb backward. The small trochanter and internal condyle of the femur, the tibia, and the great toe in the lower limb are pre-axial, and correspond respectively to the great tuberosity and outer condyle of the humerus, the radius, and the thumb in the upper limb, etc. The patella in the lower limb and the olecranon in the upper have no corresponding parts in the other limb.

The adult human skeleton is adapted in every part to maintain with ease the erect attitude by being nearly balanced around the line of the centre of gravity in the standing posture, and in this respect it differs from that of other mammals. Stability and strength are provided in the lower limbs, mobility and lightness in the upper.

THE SKULL.

The bones of the head, composing the skull, contain and protect the brain and sense-organs, as well as the commencement of the alimentary and respiratory tracts. With the exception of the lower jaw, the bones are immovably joined together by sutures, forming a bilaterally symmetrical, spheroidal figure, somewhat compressed laterally. The skull is supported upon the vertebral column, with the upper segment of which it articulates. For description, the twenty-two bones of the skull are divided into two sets. The *cranium*, or brain-case, is the part above and behind, and comprises eight bones—viz.:

Basilar bones,	Occipital. Sphenoid. Two temporals. Ethmoid.	Roof bones,	Two parietals. Frontal.

The *face* is the lower and fore part, composed of six pairs and two single bones, or fourteen in all—viz.: in pairs, the maxillæ, palate, inferior turbinate, nasal, lachrymal, and malar; single bones, the vomer and mandible. The hyoid bone may also be classed here, as appendicular to the bones of the head. The base of the skull is preformed in cartilage, the roof and sides in membrane.

THE BONES OF THE CRANIUM.

THE OCCIPITAL BONE.

This lozenge-shaped bone (Figs. 204 and 205) forms the back and a part of the base of the skull. Its long diameter is directed from behind downward and forward. It consists of four parts, which meet around the *foramen magnum.* These parts are distinct at birth, and are represented by separate bones in lower vertebrates. Of these parts, the broad, flat, curved portion behind the foramen magnum, called the *squamo-occipital,* consists of two parts. The upper triangular segment lying above the highest curved line represents the *interparietal bone* of lower vertebrates, and is sometimes separate in man. The two *exoccipitals* or *condylar portions* lie one on either side of the foramen magnum, and include the

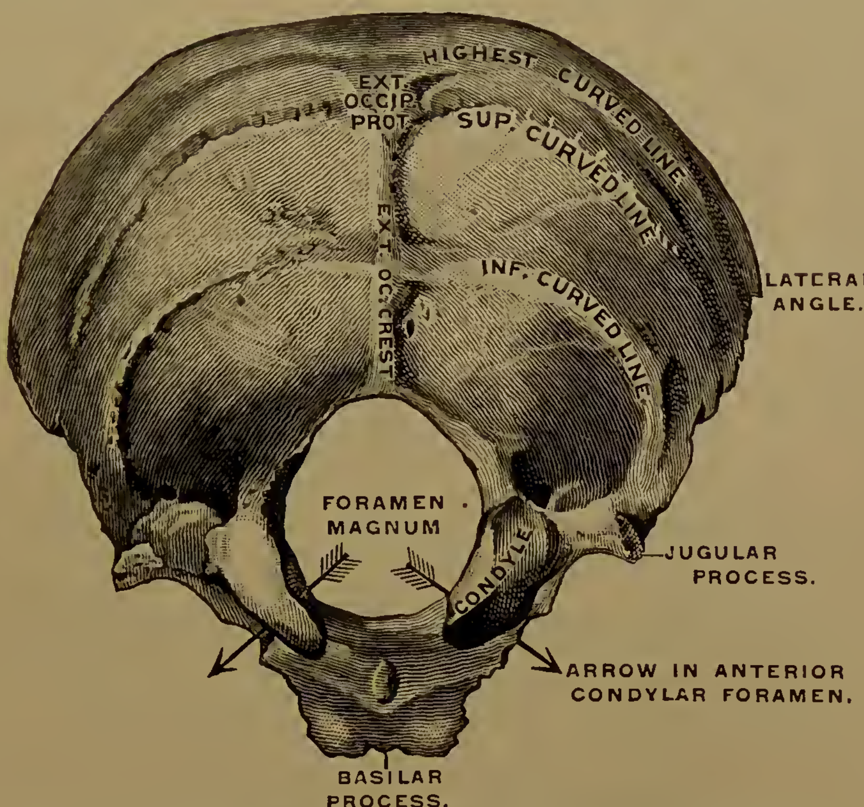


FIG. 204.—The occipital bone, viewed from below. (Spalteholz.)

condyles and jugular processes. They join the squamo-occipital behind and the *basi-occipital* or *basilar process* in front. The latter extends forward from the foramen to the sphenoid bone. The entire bone is flattened and much curved, and presents a concave cerebral surface and a convex external surface.

The **external surface** is convex, and looks downward and backward behind, downward and forward in front. It presents behind, about the centre of the squamous portion, a well-marked prominence, the *external occipital protuberance*—an important landmark to be felt through the scalp. From this a median ridge, the *external occipital crest,* leads to the back of the foramen magnum. The protuberance and crest give attachment to the ligamentum nuchæ. A transverse ridge extends laterally on each side from the external occipital protuberance called the *superior curved line* (or middle nuchal line). It arches outward toward the lateral angle, and gives origin to the trapezius internally, and parts of the occipitalis, sterno-cleido-mastoid, and splenius capitis externally. Above this line is sometimes to be seen a fainter ridge, the *highest curved line* (linea suprema or superior nuchal line). This is more curved, most marked mesially, and extends laterally toward the lateral angle, enclosing with the superior curved line a smooth, dense, semilunar area. This line is often absent, but when present gives attachment to the epicranial aponeurosis and a few fibres of the occipitalis. The surface above this line is evenly convex. The rough surface between the superior curved line and the foramen magnum is divided into two rough areas on each side by the *inferior curved* (or nuchal) *line,* which curves outward and then downward from near the middle of the crest to the jugular process. The space above the inferior line

receives the complexus mesially. The lower space is occupied by the recti capitis posteriores major and minor and the obliquus superior. On the *external* or under *surface of the condylar portions* we see the *condyles*, which lie at the sides of the anterior half of the foramen magnum. Through them the head rests upon and articulates with the atlas. Their smooth, elliptical, convex surfaces, cartilage-clad in the recent state, converge in front and look downward and outward. On the median side of each is a rough impression or *tubercle* for the lateral odontoid or check-ligaments. Behind each condyle is a depression, the *posterior condylar fossa,* which receives the hind edge of the articular facet of the atlas in extension of the head. At the bottom of the depression is sometimes seen the external opening of the *posterior condylar foramen,* for the passage of a vein from the lateral sinus. It is sometimes absent on one or both sides. The base of the condyle is traversed by the *anterior condylar foramen,* which passes outward and forward from the cranium above the foramen magnum, and transmits the hypoglossal nerve. External to each condyle the *jugular* (from *jugulum,* "throat") *process* presents an inferior rough surface, which lies above the transverse process of the atlas, and gives insertion to the rectus capitis lateralis. *The inferior surface of the basilar portion* is inclined upward, is narrower in front than behind, and is transversely convex. It presents a small median *pharyngeal tubercle,* to which is attached a process from the fibrous aponeurosis of the pharynx. On either side of this it is rough for the recti capitis anteriores, major and minor. A part of this surface can be palpated, though not easily, through the mouth.

On the **internal or cerebral surface** the *squamous* ("scaly") *portion* presents a concave surface divided by a transverse and a longitudinal ridge into four fossæ, the two superior for the occipital cerebral lobes and the two inferior for the cerebellar hemispheres. The intersection of these ridges is marked by the *internal occipital protuberance.* The longitudinal ridge above the protuberance extends to the superior angle, and is grooved for the superior longitudinal sinus, to the edges of which the falx cerebri is attached. The transverse ridges extend to the lateral angles and are similarly grooved for the lateral sinuses. The tentorium cerebelli is attached to the edges of the groove. The groove for the longitudinal sinus passes to one side, usually the right, of the internal occipital protuberance, where the groove is deeper and lodges the *torcular Herophili* ("wine-press of Herophilus"). The sharp vertical ridge below the protuberance, called the *internal occipital crest,* gives attachment to the falx cerebelli. It passes to the foramen magnum and spreads out into its margin. On the upper surface of the *jugular process* is seen a deep groove leading to a notch, the *jugular notch,* on the anterior border of the jugular process. This notch with a similar one on the petrous portion of the temporal bone forms the *jugular foramen* (foramen lacerum posterius). The groove lodges part of the sigmoid or terminal portion of the lateral sinus. Separating this groove from the foramen magnum is the *jugular eminence,* with the intracranial opening of the anterior condylar foramen internally, and that of the posterior condylar foramen externally (on the side of the groove). The upper surface of the *basilar process* presents a central groove, the *basilar groove,* slanting upward and forward for the oblongata. On either margin of this surface is half of the groove for the inferior petrosal sinus.

Angles.—The *superior angle,* as well as the two lateral, belong to the squamous portion. It fits into the angle formed by the meeting of the posterior superior angles of the parietal bones, and corresponds to the posterior fontanelle in the fœtus. The *lateral angles* at the outer ends of the superior curved lines occupy the angles between the parietal bone and the mastoid portion of the temporal on either side. The *anterior* or *inferior angle* is represented by the oblong, anterior surface of the basilar portion, united to the body of the sphenoid by cartilage until the age of twenty years, afterward by bone.

Borders.—The *two superior borders* extend between the superior and lateral angles, and are convex and deeply serrated. They articulate with the posterior borders of the parietals, and form the *lambdoid* ("lambda-like") or *parieto-occi-*

pital suture. The *two inferior borders* extend between the lateral and antero-inferior angles, and are uneven and less deeply serrated. Between the lateral angles and the jugular processes they articulate with the mastoid portions of the temporals in the *occipito-mastoid suture.* The small rough extremity of each jugular process articulates with the jugular facet of the petrous portion of the temporal bone by synchondrosis until about the twenty-fifth year, when the union becomes osseous. In front of the jugular process is the smooth jugular notch (see above). Between this notch and the antero-inferior angle the borders are rough for articulation with the petrous portion of the temporal bone. A somewhat octagonal form is not infrequently presented by this bone, due to the projection of the jugular processes and the middle of the superior borders.

The *foramen magnum* is oval in shape, with the long axis directed from before backward. It is encroached upon laterally in its fore part by the condyles, and transmits the upper end of the spinal cord with its membranes and accompanying structures. From the condyles, thick ridges of bone, which strengthen the skull and transmit its weight to the condyles, pass in four directions—viz., for-

FIG. 205.—The occipital bone, viewed from above. (Spalteholz.)

ward into the basilar process, laterally into the jugular processes, backward around the foramen, and thence upward as the occipital crest, etc.

Development.—The basilar and condylar portions ossify each from a single centre. The squamous portion has four centres in two laterally disposed pairs—a pair above in the interparietal portion, and a pair below in the supraoccipital portion. These two pairs usually unite, but may remain separate through life, forming an interparietal bone, as in lower vertebrates; or, more commonly, two lateral fissures remain, a condition usually found at birth. The condylar portions join the squamous in lines extending outward from the posterior margin of the foramen magnum, and they join the basilar portion in lines passing through the anterior extremities of the condyles. The centres for the interparietal portion are deposited in membranes, those for the rest of the bone in cartilage.

Varieties.—There is sometimes seen a groove for the occipital sinus along the internal occipital crest. The jugular notch is often found partly subdivided by a small *intrajugular process*, and it is frequently separated from the groove for the sinus by a thin transverse ridge. A projection sometimes found beneath the jugular process, the *paramastoid process* of many mammals, may rarely be so

long as to meet the transverse process of the atlas. Frequently the anterior condylar foramen is subdivided by a thin bony spicule. Rarely the basilar process at the margin of the foramen articulates with the odontoid process. A median membranous space from the foramen magnum backward to the middle of the supraoccipital is of interest, because in rare cases, when not ossified, it may allow hernia of the brain and its membranes.

Articulations.—By sutures the occipital bone is connected with the two parietals, the two temporals, and the sphenoid, and by the condyles it articulates with the atlas.

THE PARIETAL BONE.

The *parietal* ("wall") *bones* (Figs. 206, 207) are two symmetrical, quadrilateral plates which form a large part of the vault and sides of the skull, and are interposed between the frontal and the occipital bones.

The **external surface** is convex, the convexity being greatest a little below and behind the centre, at the *parietal eminence*, most marked in young bones. Arching across the bone just below this are the *superior* and *inferior temporal ridges*, the bone between which is smoother than elsewhere. The *lower ridge*, better marked

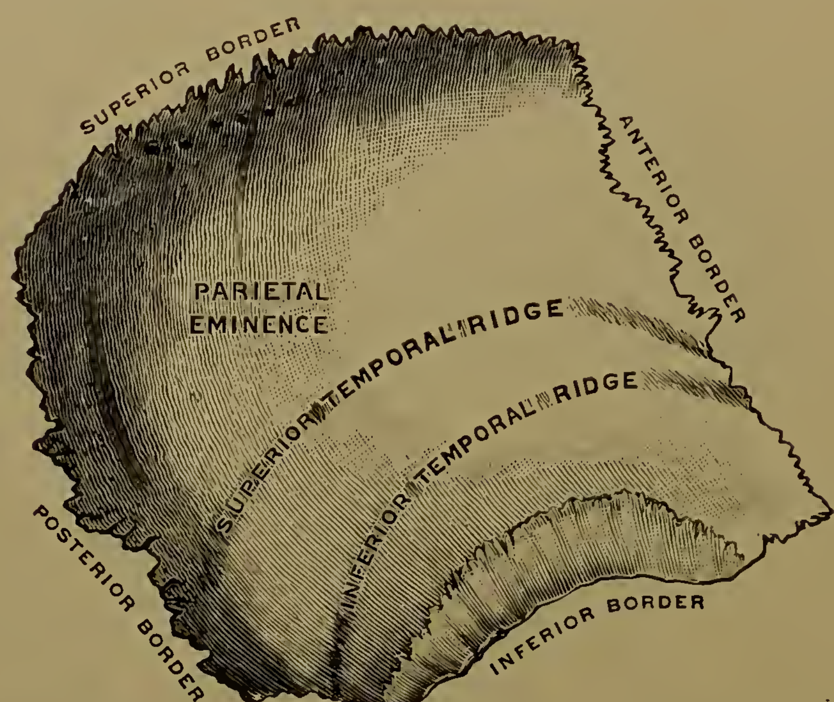


FIG. 206.—The right parietal bone, outer surface. (Gegenbauer.)

and more constant, limits the temporal fossa and the attachment of the temporal muscle. The *upper ridge*, when present, gives attachment to the temporal fascia. The surface above it is covered by the scalp. Not far from the hind end of the upper border is the small *parietal foramen* when present.

The **internal surface** is concave, and marked by shallow depressions and ridges for the cerebral convolutions, and by narrow grooves for branches of the middle meningeal artery, which run upward and backward from below. The largest of these runs from the projecting *anterior inferior angle*, often as a canal, for a short distance, and is useful in determining the side to which the bone belongs. Along the superior border is a half-groove, completed by the one on the opposite bone, and lodging the superior longitudinal sinus. Near this groove, in the bones of adults, and especially of the aged, small irregular depressions for the Pacchionian bodies are seen. A small part of the groove for the lateral sinus usually crosses the inner aspect of the posterior inferior angle.

Borders.—The *superior*, *anterior*, and *posterior borders* are deeply serrated, and the latter two, and to a less extent the first, are alternately bevelled at the expense of the outer and inner surfaces, thus alternately overlapping and being overlapped by the adjacent bones. The bone is thus so strongly wedged in as to prevent dis-

location and to strengthen the cranial vault. The superior border forms with that of the opposite bone the *sagittal* ("arrow-like") *suture*. The anterior borders of the two parietal bones articulate with the frontal bone in the *fronto-parietal* or *coronal* ("crown") *suture*, and meet the sagittal suture at nearly a right angle in European skulls, while the posterior borders, which form the *lambdoid suture* by articulation with the occipital, meet the sagittal suture at an obtuse angle. The *inferior border* has three divisions. Behind, it is serrated for a short distance to articulate with the mastoid portion of the temporal bone in the *parieto-mastoid suture*. In front of this the border is thin, concave, and externally bevelled and fluted, where it is overlapped by the squamous portion of the temporal in the *squamous suture*. The great wing of the sphenoid overlaps the front inch or so, forming the *spheno-parietal suture*.

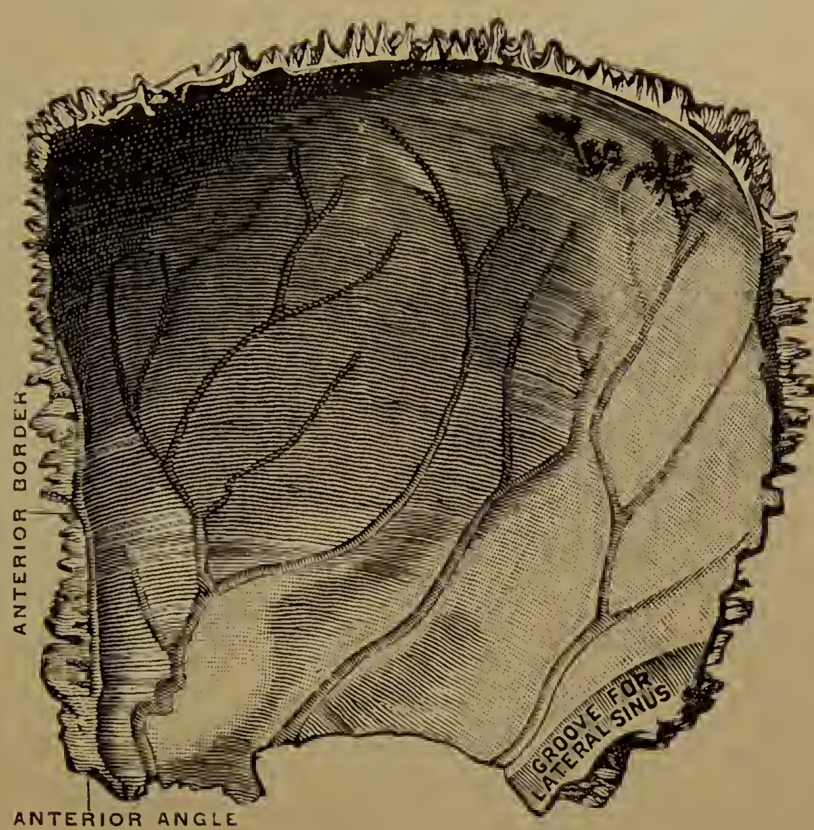


FIG. 207.—The right parietal bone, inner surface. (Testut.)

Angles.—Of the superior angles the anterior is at the *bregma* ("sinciput"), the posterior at the *lambda* (Greek letter Λ). The projecting anterior inferior angle is at the *pterion* ("wing"), and is sometimes excluded from articulation with the sphenoid by the contact of the squamosal and frontal.

Ossification occurs in membrane from a single centre and commences at the site of the parietal eminence.

Varieties.—Rarely a horizontal suture divides the bone into two parts. A large opening is very rarely seen at the site of the parietal foramen.

THE FRONTAL BONE.

The *frontal* ("forehead") *bone* (Figs. 208–210) forms the skeleton of the forehead, and receives the frontal lobes of the brain in the concavity between the main or *vertical portion*, which arches upward and backward from the orbital margins, and the two thin horizontal or *orbital plates*, which extend backward from the same points, separated by a median gap, the *ethmoidal notch*.

The **anterior** or **external surface** is convex, and most strongly so at the *frontal eminences*, a little below the centre of each lateral half. Below and separated from these by shallow grooves are the arched *superciliary* ("above the lashes") *ridges*, converging in the median line to the *nasal eminence*, below which is the smooth *glabella* ("little smooth place"). Traces of the *metopic* ("frontal") *suture*, which originally separated the two halves of the frontal, usually persist in the glabella. Behind the superciliary ridges lie the *frontal sinuses*, which cause the prominence of the ridges in the male. The arched *supraorbital* ("above the orbit") *ridges*, more sharply marked externally, limit this surface below and form the anterior margin of the orbital roofs. At about the junction of their inner and middle thirds is the *supraorbital notch*, sometimes a foramen, for the supraorbital nerve and artery. The supraorbital arch ends in two downward projections, the *external* and *internal angular processes*, of which the external is a strongly projecting landmark, which articulates with the malar bone, while the internal is slightly marked and articulates with the lachrymal bone. From the external angular process the *temporal crest* arches upward and backward, continuous with the temporal ridges

on the parietal bone. It separates the frontal portion of this surface from the temporal portion, below and behind it, which forms part of the temporal fossa and gives origin to the temporal muscle.

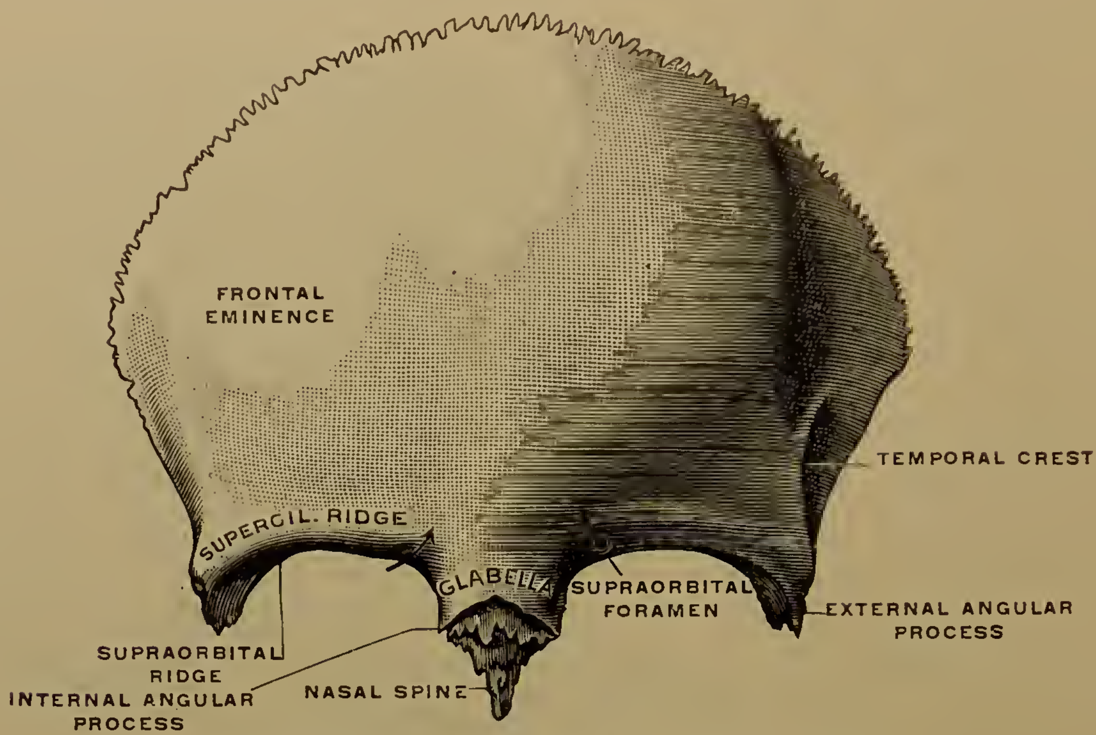


FIG. 208.—The frontal bone, seen from in front. (Testut.)

The **inferior surface** consists of the orbital surfaces of the triangular *orbital plates,* which form the greater part of the roof of the orbits. Their inner margins are parallel; the outer pass backward and inward. Close behind the outer part

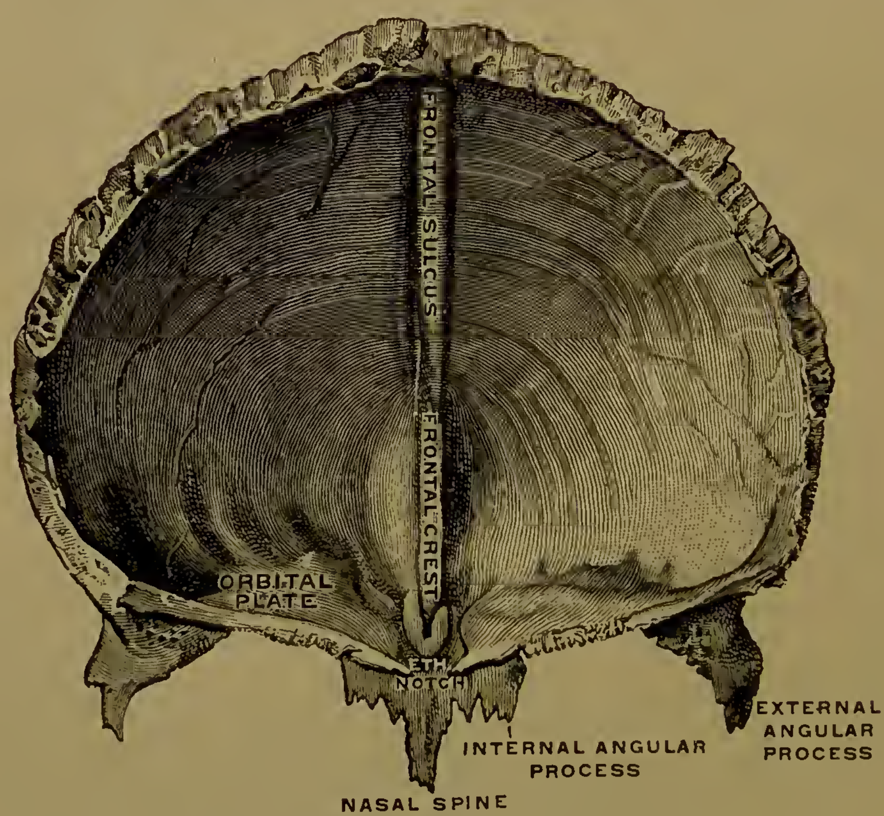


FIG. 209.—The frontal bone, seen from behind. (Spalteholz.)

of the supraorbital ridge this surface presents the *lachrymal fossa* lodging the lachrymal gland; and behind the inner end of the ridge there is a depression, the *trochlear fossa* (more rarely a tubercle), for the pulley of the superior oblique muscle of the orbit. Between and in front of the internal angular processes is the *nasal notch.* This is bounded above by a semilunar, serrated surface, which articulates with the upper ends of the nasal bones mesially and the nasal processes of the superior maxillæ laterally. It is bounded behind by a rough, nearly vertical surface, the *nasal process* (Henle), which projects down behind, supports and articulates with the posterior aspect of the upper ends of the nasal and maxil-

lary bones, which form the bridge of the nose. From the centre of the nasal process the *nasal spine* projects downward and forward as a sharp process, and between the crests of the nasal bones and the vertical plate of the ethmoid forms a part of the septum of the nose. The spine commences behind the nasal process as a median ridge, on either side of which is a narrow groove forming a small part of the roof of the nasal fossæ. Between the back of these grooves and the internal angular process notice the openings of the two *frontal sinuses,* which lie between the outer and inner tables of the bone. The sinuses lie behind the superciliary ridges, extend a variable distance over the orbits, and are separated from one another by a thin vertical partition, usually displaced to the left. Behind these openings, and between the ethmoidal notch and the inner margins of the orbital surfaces, are a series of depressions forming the roofs of cells, and two transverse grooves. These are completed by articulation with the lateral masses of the ethmoid to form, respectively, the *ethmoidal cells* and the *anterior* and *posterior ethmoidal canals.* The anterior canal transmits the nasal nerve and the anterior ethmoidal vessels; the posterior canal, the posterior ethmoidal vessels.

The **cerebral surface** forms a deep concavity, encroached upon but slightly by the convexity of the upper surfaces of the orbital plates, which form the greater part of the floor of the anterior cranial fossa. The orbital plates and the adjoining bone present marked depressions and ridges for the frontal convolutions.

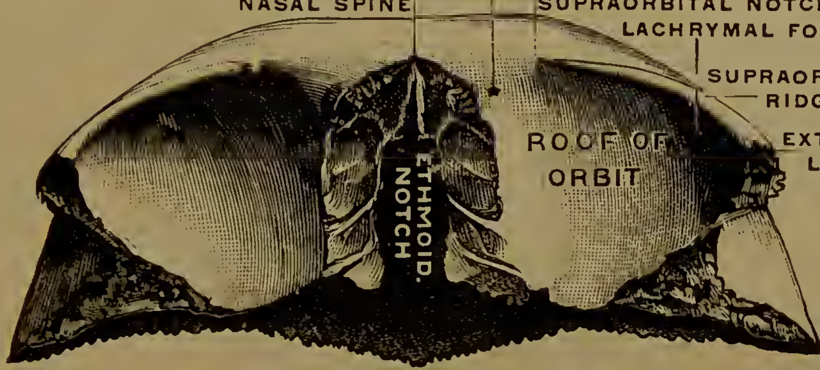


FIG. 210.—The frontal bone, seen from below. (Testut.)

Elsewhere the bone is smoother, except for a median furrow, the *frontal sulcus.* This starts from the upper border, with pits for Pacchionian bodies on both sides, and narrows down below to the thin, prominent *frontal crest.* The superior longitudinal sinus is lodged in the sulcus, and the falx cerebri is attached to the crest and the ridges of the sulcus. The termination of the crest, by articulation with the crista galli of the ethmoid, completes the *foramen cæcum* ("blind hole"). When not closed below, this foramen transmits a small vein from the nose to the superior longitudinal sinus.

Borders and Articulations.—The *posterior border* articulates with the parietal bone in the *coronal suture,* nearly as far outward as a rough triangular surface. This triangular surface articulates with the great wing of the sphenoid, and forms the posterior half of the outer margin of the orbital plate. It is continuous behind with the thin posterior margin of the orbital plate, which articulates with the small wing of the sphenoid. The malar bone articulates with the fore part of the outer margin of the orbital plate. The parallel inner borders of the orbital surface articulate with the os planum of the ethmoid behind and the lachrymal in front. The margins of the ethmoidal notch articulate with the cribriform plate of the ethmoid laterally, and the crista galli in front. (The articulations of the nasal notch, process, and spine have been described above.)

Ossification proceeds from two centres in the membrane at the site of the frontal eminences. At birth there are two separate lateral halves, soon united by the median *frontal* or *metopic suture,* which is usually obliterated by ossification, except for a trace at the glabella; but sometimes it persists throughout life. The frontal sinuses appear about the seventh year as forward growths from the ante-

rior ethmoidal cells, and increase up to old age. They may invade and extend over the roof of the orbit quite extensively.

THE TEMPORAL BONE.

The *temporal* ("temple") *bone* (Figs. 211–214) forms part of the side and base of the skull, contains the organ of hearing, and articulates with the lower jaw. Although it is usually described in three parts—viz., squamous, mastoid, and petrous—the three parts separable at birth are the squamous, petro-mastoid, and tympanic.

The Squamous Portion.—This is a thin plate, which extends upward and forward at right angles to the petrous, and forms part of the side-wall of the middle fossa of the skull. The *outer surface*, but slightly convex, is smooth, except for a vertical groove above the external auditory meatus for the middle temporal artery. It forms part of the temporal fossa, which is separated from the mastoid surface behind by the curved *supramastoid crest*. This crest is continued forward, just above the external auditory meatus, to the *zygoma* ("yoke"), a process of bone

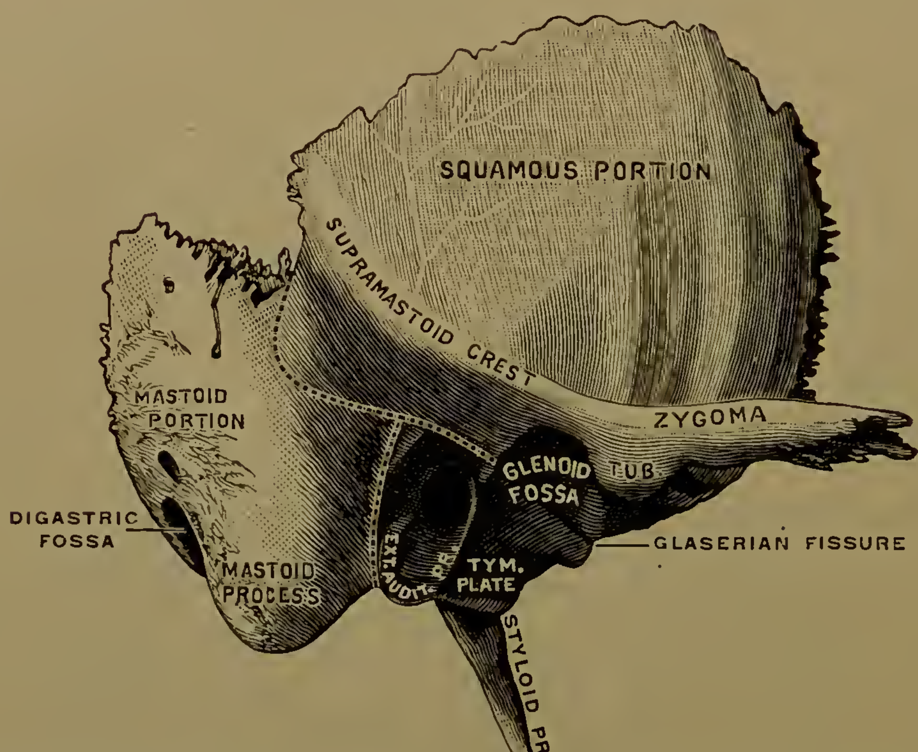


FIG. 211.—The right temporal bone, outer surface. The dotted lines indicate the lines of suture between squamous, mastoid, and tympanic portions. (Testut.)

which projects outward in a shelf-like manner from the lower part of this surface, and then, twisted on itself, continues forward. In its forward projection the smooth inner surface and lower border give origin to the masseter, the sharp upper border gives attachment to the temporal fascia, and the serrated and bevelled anterior extremity articulates with the malar. Two ridges, or *roots*, extend from its base, the posterior backward and the anterior inward, enclosing between them a transversely oval, smooth depression, the *glenoid fossa*, divided into two parts by the nearly transverse *fissure of Glaser*. For articulation with the lower jaw the front half of the fossa is coated with cartilage, together with the convex nearly transverse ridge, the *eminentia articularis*, which limits it in front and forms the anterior root of the *zygoma*. At the outer end of the latter root is a tubercle (preglenoid) for attachment of the external lateral ligament of the lower jaw. The posterior root divides into two branches, of which the upper is the supramastoid crest, and the lower ends in front of the external auditory meatus at the Glaserian fissure as the *postglenoid process*, very prominent in young bones. In front of the articular eminence is a small, smooth triangular surface belonging to

the zygomatic fossa, and separated from the temporal surface by a slight ridge. The external pterygoid muscle glides over this surface.

The *internal surface* is marked by impressions for the cerebral convolutions and by grooves for the middle meningeal arteries. Where it joins the petrous portion there is seen in young, and often in old, bones the remains of the *petro-squamous suture* passing from the angle between these two portions in front to the *parietal notch* between the squamous and mastoid portions behind. The *arched border* between these two angles or notches describes about two-thirds of a circle, and above is thin, bevelled, and fluted on its inner surface, overlapping the

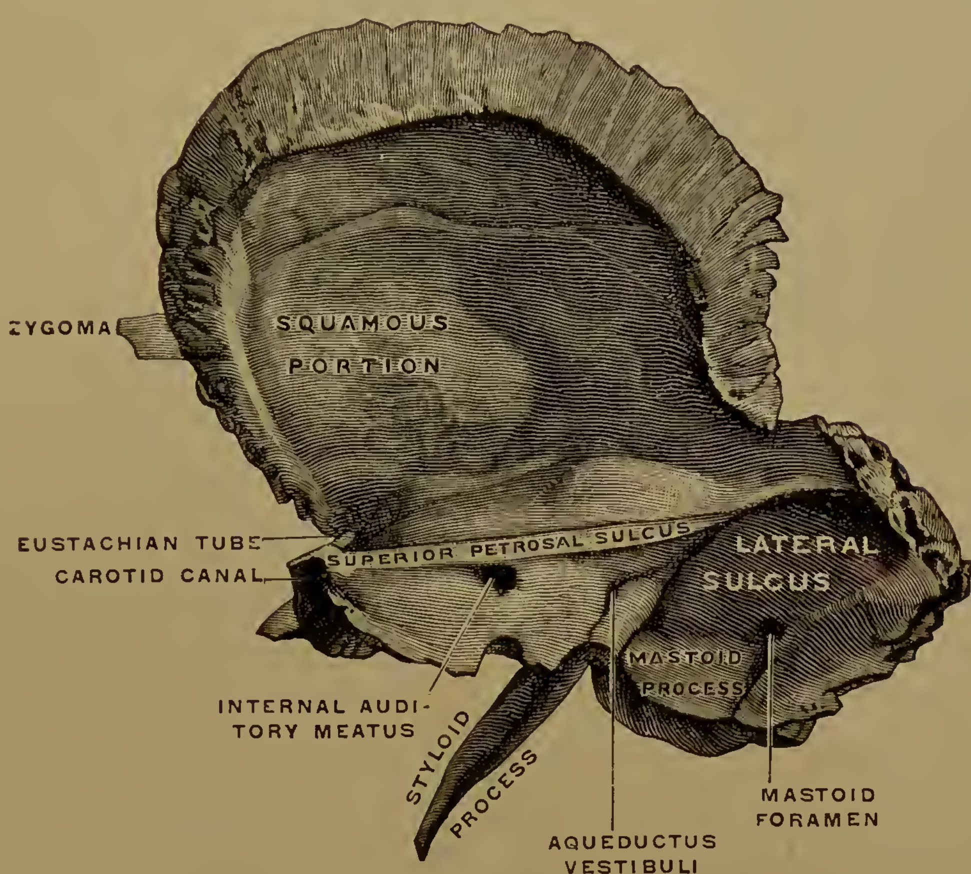


FIG. 212.—The right temporal bone, viewed from the mesial plane. (Testut.)

parietal, and in front is serrated and bevelled on its inner surface above and on its outer surface below, articulating with the great wing of the sphenoid.

The Petro-mastoid Portion.—This segment of the temporal is an irregular, four-sided pyramid of very dense bone, whose rough truncated apex is directed forward and inward to the foramen lacerum medium, and whose base, directed outward and backward, is formed by the less dense mastoid portion. It is usually described as three-sided, the fourth or outer surface being mostly covered by the tympanic bone.

The **mastoid portion** of the petrosal presents a triangular rough *external surface*, prolonged downward and forward into the nipple-shaped *mastoid process*, which affords attachment to the sterno-mastoid, splenius capitis, trachelo-mastoid, and occipitalis. Internal to the mastoid process is the deep *digastric groove* for the digastric muscle, internal to which is a shallow groove for the occipital artery. Its *internal* or *cerebral surface* forms a small part of the posterior cranial fossa, and is separated from the petrosal pyramid by the deep groove for the sigmoid portion of the lateral sinus. The *mastoid foramen*, transmitting a vein, opens internally on or near the rear wall of this groove, and externally near the posterior border of the mastoid portion. The *upper border* of this portion articulates with the parietal, the *posterior border* with the occipital. The suture-line between the squamous and mastoid portions lies a little below the supramastoid crest, and runs from the parietal notch to the middle of the external meatus. The mastoid process, nearly flat at birth, becomes pronounced externally about the second year. As it enlarges, it becomes filled with a number of connected cancellous spaces, which about puberty are in whole or in part converted into air-cells (*mas-*

toid cells). These are connected with a larger cavity, the *mastoid antrum* ("cave"), which is present and comparatively large at birth, and communicates with the upper part of the middle ear or tympanum. The antrum is bounded externally by that part of the squamous portion below the supramastoid crest, which is exceedingly thin in children, while superiorly a continuation backward of the roof of the tympanum (*tegmen tympani*, "cover of the drum") separates it from the middle cranial fossa.

FIG. 213.—Section through the mastoid cells, showing their communication with the middle ear. (W. W. Keen.)

The petrous portion.—Of the two intracranial surfaces of this portion, the *posterior surface* looks backward, inward, and slightly upward into the posterior fossa of the base of the skull. From near its centre the *internal auditory meatus*, which transmits the facial and auditory nerves, passes outward for about two-fifths of an inch to a plate of bone, the *lamina cribrosa* ("sieve-like layer"). This is so called from the number of larger and smaller apertures for the subdivisions of the eighth or auditory nerve on either side of a transverse *falciform* ("sickle-shaped") *crest*, above which, in front, is the internal orifice of the *aqueduct of Fallopius* for the seventh or facial nerve. The aqueduct of Fallopius passes outward to the *genu*, where it bends backward to pass along above and internal to the tympanum, behind which it bends sharply downward internal to the opening between the tympanum and antrum, and terminates at the *stylo-mastoid foramen*. Behind the meatus is the small, slit-like opening of the *aqueductus vestibuli* ("water-pipe of the vestibule"), occupied in the adult by vessels and a process of the dura, and above and in front of the latter is a small opening, the remains of the *floccular fossa*, very large in young bones.

The *anterior surface* looks forward, outward, and upward into the middle cranial fossa. A depression is seen near the apex for the Gasserian ganglion. Behind and external to this are two small grooves leading backward and outward to foramina—the larger and internal to the *hiatus* ("gaping") *Fallopii*, which leads to the geniculate ganglion in the aqueduct of Fallopius, and transmits the great superficial petrosal nerve, while the smaller and external is for the small petrosal nerve. Behind these, and between the petro-squamous suture externally and an eminence formed by the superior semicircular canal internally, the bone is thin and forms the roof of the tympanum.

The *inferior* or *basilar surface* presents posteriorly, between the mastoid and styloid processes, the *stylo-mastoid foramen*, the exit of the facial nerve from the aqueduct of Fallopius. The *styloid process* itself projects downward and forward, for possibly 2 inches, from its base, which is imbedded between the vaginal process of the tympanic bone and the petrosal bone. It gives attachment to two ligaments and three muscles. Internal to this foramen and process is the small quadrilateral *jugular facet*, with which the jugular process of the occipital unites by cartilage, which ossifies about the twenty-fifth year. In front of and internal to this facet is the smooth, deep *jugular fossa*, which with the jugular notch of the occipital completes the jugular foramen. In front of the fossa is the *carotid foramen*, the lower end of the *carotid canal* (for the internal carotid artery) which ascends vertically, and then passes horizontally forward and inward to the outer side of the apex of the bone at the *foramen lacerum medium* ("middle torn hole"). Internal to the carotid foramen and reaching to the apex is a quadrilateral surface for the origin of the tensor tympani and levator palati muscles. *Small Foramina on this Surface.*—1. Between the jugular fossa and the carotid foramen is the *tympanic*

canaliculus for Jacobson's nerve (the tympanic branch of the glosso-pharyngeal). 2. In the jugular fossa is the foramen for the auricular branch of the vagus nerve. 3. Small tympanic branches of the carotid plexus pierce the walls of the

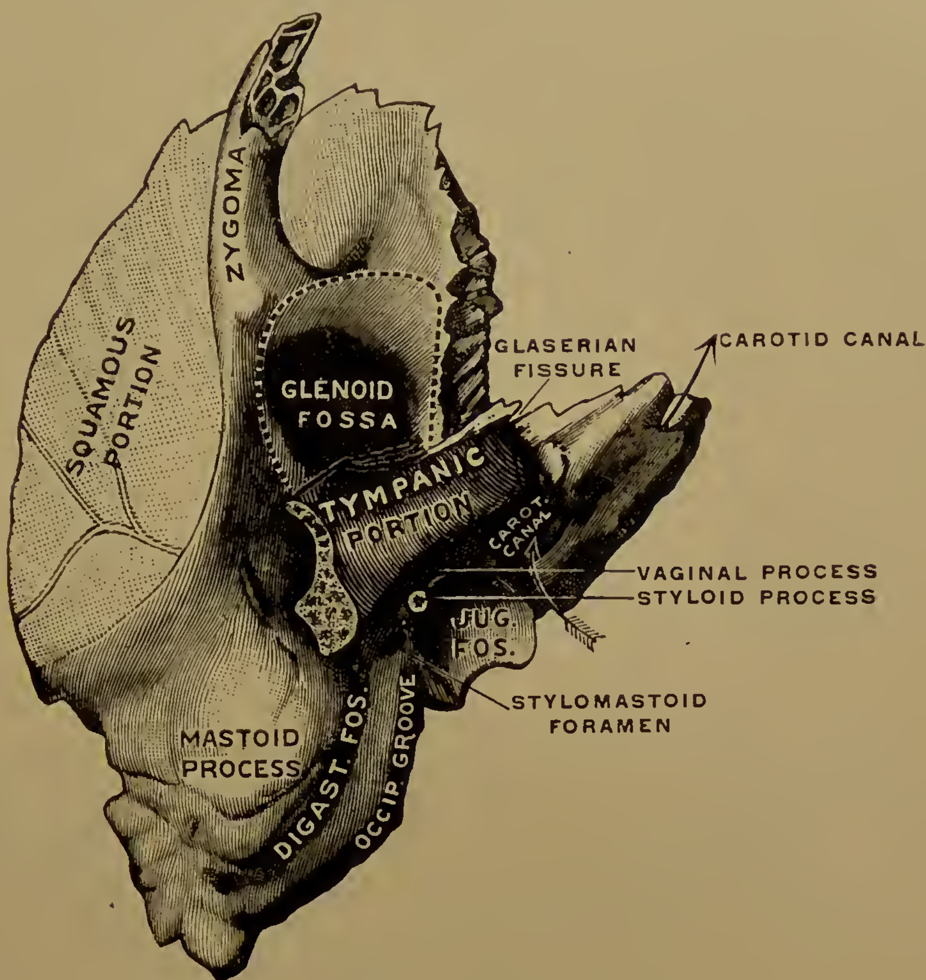


FIG. 214.—The right temporal bone, viewed from below. (Testut.)

carotid canal. 4. The aqueduct of the cochlea begins in a triangular depression on the postero-inferior margin, just below the internal meatus.

The narrow *external* or *tympanic surface* looks slightly forward, and is hidden by the tympanic plate, except for a variable extent of the outer wall of the carotid canal in front. On removal of the tympanic bone this surface is seen to form the *inner wall of the tympanum* ("drum"). In the angle between it and the tympanic roof is seen the bulging of the *Fallopian canal,* which bends downward in the angle between the inner and posterior tympanic surfaces, and lodges the facial nerve. Below this is the *fenestra ovalis* ("oval window"), opening into the vestibule and situated above the *promontory,* which is grooved for the tympanic plexus of nerves. Below and behind the promontory is the *fenestra rotunda* ("round window"), opening into the cochlea. The surface narrows in front to the bony canals for the tensor tympani muscle above and the Eustachian tube below, which are completed externally by the tympanic plate. The two canals are separated by the delicate *processus cochleariformis* ("conchshell-shape"), which projects outward and upward.

FIG. 215.—Squamous portion and tympanic ring of the temporal bone at birth.

The *superior border,* grooved for the superior petrosal sinus, gives attachment to the tentorium cerebelli, a process of which bridges over a notch (*trigeminal notch*) near the apex of the bone for the passage of the trigeminal or fifth nerve. A spicule of bone near the front end of this border is often continued by a fibrous band, rarely by bone (*petro-sphenoidal ligament* or process), to the side of the dorsum sellæ of the sphenoid, completing a foramen for the sixth nerve and the inferior petrosal sinus. The *posterior inferior border,* internal to the jugular foramen, completes the groove for the inferior petrosal sinus by its articulation with

the occipital bone. The *anterior superior* and *anterior inferior borders* are shortened by articulation with the squamosal and tympanic bones, respectively. The angle between the squamous and petrous portions receives the spine of the sphenoid and presents the front orifice of the bony *Eustachian canal*, to which the cartilaginous part is attached.

The Tympanic Bone.—In the adult this part of the temporal forms the *tympanic plate.* This constitutes the posterior, non-articular portion of the glenoid fossa, which lodges part of the parotid gland, and is separated from the squamous portion in front by the Glaserian fissure. Inferiorly it forms the sharp, projecting *vaginal* ("sheath-like") *process;* superiorly it coalesces with the squamous portion, and forms the front, lower, and part of the rear walls of the bony external auditory meatus. The latter projects outward in the curved, rough, free margin of the *external auditory process,* which gives attachment to the cartilaginous part of the external auditory meatus. Internally it fuses with the petrosal, and forms the outer wall of the tympanum. Posteriorly it joins the mastoid portion in the *auricular fissure,* behind the external auditory meatus.

The bony *external auditory meatus* is elliptical, slightly constricted in the middle, and directed inward and a little forward to the tympanum. Its internal orifice is smooth and grooved for the tympanic membrane; the external orifice is bounded by the external auditory process of the tympanic bone except above, where the posterior root of the zygoma bounds it. Externally the Glaserian fissure is closed; internally it is double, and is occupied by a descending process of the tegmen tympani of the petrous portion, which separates the tympanic and squamosal bones, and forms most of the outer wall of the Eustachian and tensor tympani canals. Between this process and the tympanic plate the fissure transmits to the tympanum the tympanic branch of the internal maxillary artery, and lodges the slender process of the malleus. More internally it presents the *canal of Huguier,* by which the chorda tympani nerve issues from the tympanum.

Articulations.—The temporal bone articulates above with the parietal, in front with the sphenoid and malar, below with the mandible, behind and internally with the occipital.

Ossification.—The squamosal and tympanic bones ossify in membrane, each from a single centre; the petrous portion and styloid process in cartilage, the former from four centres, the latter from two. The fœtal tympanic bone forms an incomplete ring, which encloses the tympanic membrane. It is open above with its free ends united to the squamosal. The defect in the ring due to this opening above is known as the notch of Rivinus. Two tubercles, one growing from the front and the other from the back of this ring, meet in the floor of the meatus, enclosing a foramen, which is gradually (though not always) closed, and thus the tympanic plate is formed. At birth the mastoid process, articular eminence, and tympanic ring are flat, the glenoid fossa is shallow, and the hiatus Fallopii opens at the genu of the canal.

THE SPHENOID BONE.

The *sphenoid* or *wedge-bone* (Figs. 216–218) forms a part of all three fossæ of the base of the skull and of the orbits and nasal fossæ. It is very irregular in shape, and consists of a body, two pairs of wings, and a pair of pterygoid processes.

Body.—The central cuboidal part or *body* present a *superior surface,* which in its hind part, in the posterior cranial fossa, continues the basilar groove of the occipital and slants upward and forward to a quadrilateral projecting plate, the *dorsum sellæ* ("back of the saddle"). The upper angles of the latter project outward as the *posterior clinoid* ("bed-like") *processes,* which give attachment to the tentorium cerebelli. It overhangs a deep depression, the *pituitary fossa* or *sella turcica* ("Turkish saddle"), which lodges the hypophysis and forms the isthmus or narrow median portion of the middle cranial fossa. This depression is bounded in front by a transverse elevation, the *olivary eminence,* behind which

on each side projects a small tubercle, the *middle clinoid process.* In front of the eminence the slight *optic groove* supports the optic commissure, and leads laterally to the *optic foramina.* The surface in front of this is on a slightly higher level, and forms part of the floor of the anterior cranial fossa. It ends in front in a projection, the *ethmoidal spine,* for articulation with the cribriform plate of the ethmoid, and laterally it is continuous with the superior surfaces of the small wings. Each lateral margin of the superior surface of the body is bevelled by the winding *cavernous groove,* which lodges the internal carotid artery in its forward passage and the cavernous sinus. The hind end of this groove is bounded on either side by a bony projection, internally by the *petrosal process,* which springs from the side of the base of the dorsum sellæ and fits against the apex of the petrous portion of the temporal bone, and externally by the *lingula* ("little tongue"), a thin lamella projecting upward and backward between the body and the great wing. The *posterior surface* is united to the basilar process of the occipital by cartilage in early life, and by bony union in the adult. On the *anterior surface* the vertical *sphenoidal crest* projects in the middle line, below the ethmoidal spine, and articulates with the vertical plate of the ethmoid. On either side, superiorly, are the rounded orifices of the *two sphenoidal sinuses,* which occupy much of the body of the bone. They are unequally divided by a vertical lamina, the sphe-

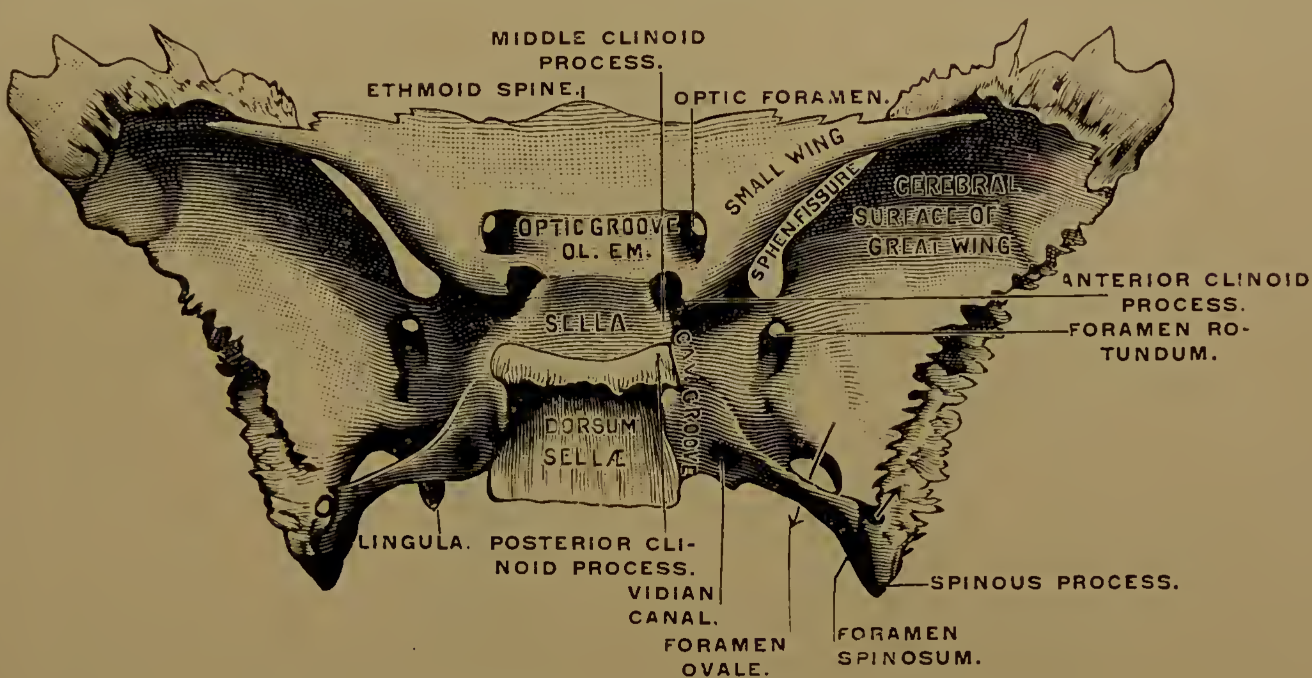


FIG. 216.—The sphenoid bone, viewed from above. (Testut.)

noidal septum, continued back from the crest. These openings and the surfaces beneath them are on the roof of the nasal fossæ, and the rough surfaces on their lateral sides articulate with the lateral masses of the ethmoid above and with the orbital processes of the palate bones below. Much of this surface on either side of the crest, internal to the articular areas and below the orifices, is formed by the *sphenoidal turbinate* ("top-shaped") *bones.* These are triangular or conical in shape, with the apex directed downward and backward. They are formed separately, often come away with the ethmoid or palate bones in disarticulating, and sometimes enter into the formation of the inner wall of the orbit. The *inferior surface* presents in front a median ridge, the *rostrum* ("beak"), continuous with the crest and received between the alæ of the vomer. The surface on either side of the rostrum forms part of the roof of the pharynx and nasal fossæ, and is partly covered by the vaginal processes of the internal pterygoid plates. Each *lateral surface* gives attachment to the two wings, and between the latter forms the inner boundary of the sphenoidal fissure and the back of the inner orbital wall.

The **small or orbital wings** are thin, triangular, horizontal plates, extending outward from the fore part of the lateral surfaces on a level with the corresponding part of the superior surface. Their smooth *superior surfaces* form the hind part of the floor of the anterior cranial fossa; the *inferior surfaces* form the back of

the roof of the orbits and the upper margin of the sphenoidal fissures. The serrated *anterior border* articulates with the orbital plate of the frontal bone, by which it and its pointed *outer extremity* are separated from the great wing, external to the sphenoidal fissure. The free *posterior border* is received into the Sylvian fissure of the brain. It is the boundary between the anterior and middle cranial fossæ, and ends postero-internally in a knob, the *anterior clinoid process*, which gives attachment to the anterior extremity of the tentorium cerebelli. The *base* of the wing is divided into two roots by the forward and outward passage of the *optic foramen*, which transmits the optic nerve and the ophthalmic artery.

The **great or temporal wings** project outward and upward from the lower part of the sides of the body, and present three surfaces—cerebral, orbital, and temporo-zygomatic. The concave *cerebral surface* forms part of the middle cranial fossa, and presents at the fore part of its junction with the body, and below the sphenoidal fissure the forwardly directed *foramen rotundum* for the superior maxillary nerve. Behind and a little external to this is the large *foramen ovale*, directed downward, for the inferior maxillary nerve. This part of the bone projects horizontally backward into the sharp *alar* ("wing-like") *spine* of the sphenoid, which occupies the angle between the squamous and petrous portions of the temporal bone. From its under surface the sharp *spinous process* projects downward, and gives attachment to the spheno-mandibular ligament. The small *foramen spinosum*

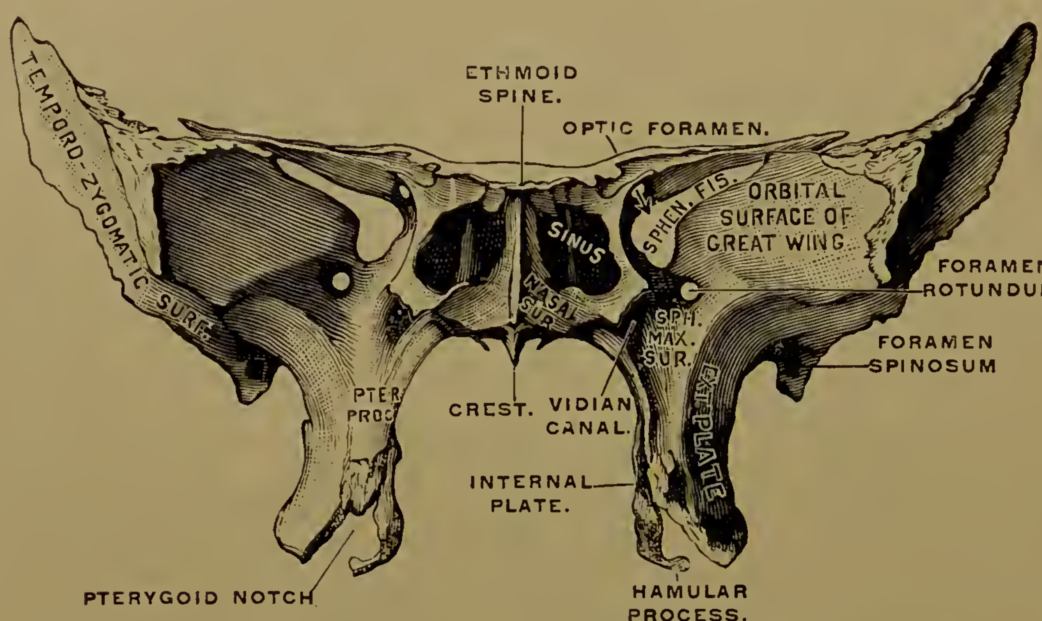


FIG. 217.—The sphenoid bone, viewed from in front. (Testut.)

perforates the spine and transmits the middle meningeal artery, grooves for which cross this surface. The *external* or *temporo-zygomatic* surface forms part of the temporal fossa above and of the zygomatic fossa below the transverse *pterygoid* ("wing-like") *ridge* which crosses it. The *zygomatic surface* looks downward, is continuous with the outer surface of the external pterygoid plate, and presents the lower orifices of the foramina ovale and spinosum. The *anterior* or *orbital surface* looks forward and inward. Its upper quadrilateral part forms the greater part of the outer wall of the orbit, which is separated by a ridge, forming the outer lip of the *spheno-maxillary fissure*, from a small area below, which looks into the spheno-maxillary fossa and presents the anterior orifice of the foramen rotundum. The *posterior border* in its inner third bounds the foramen lacerum medium in front, and presents the posterior opening of the *Vidian canal.* This canal tunnels the base of the internal pterygoid plate sagittally and transmits the Vidian nerve and artery. In its outer two-thirds this border articulates with the petrosal, completing inferiorly a groove for the cartilage of the Eustachian tube. The *external border* is bevelled internally below and externally above, and articulates with the squamosal. The *superior border* overlaps the anterior inferior angle of the parietal bone. Internal to and in front of this articulation is a rough triangular surface, formed between the upper margins of the three surfaces, which

rticulates with a similar rough triangular surface on the frontal. The cranial nd orbital surfaces converge and meet in a sharp free border which bounds the *phenoidal fissure* inferiorly. The *anterior margin* or *malar crest* separates the rbital and temporal surfaces, and articulates with the malar bone and sometimes ith the superior maxilla at its lower angle. The obliquely elongated *sphenoidal issure* between the body and the two wings is closed externally by the frontal one, and transmits to the orbit the third, fourth, sixth, and ophthalmic divisions f the fifth nerves, and the ophthalmic vein.

The **two pterygoid processes** consist each of two plates, joined in front, but iverging behind, which project downward and slightly forward from the lower spect of the base of the great wing.

The **external pterygoid plate,** broad and thin, lies in a plane directed backward nd outward. The *internal surface* affords origin to the internal pterygoid muscle, he *external surface* to the external pterygoid muscle. This plate forms the inner oundary of the zygomatic fossa, and the outer boundary of the *pterygoid fossa,* which lies between and behind the two plates.

The **internal pterygoid plate,** longer and narrower than the external, forms the uter boundary of the posterior naris, where it is partly covered by the sphenoidal rocess of the palate-bone. From the upper end of its internal surface on each ide a thin plate, the *vaginal process,* projects inward to articulate with the ala of

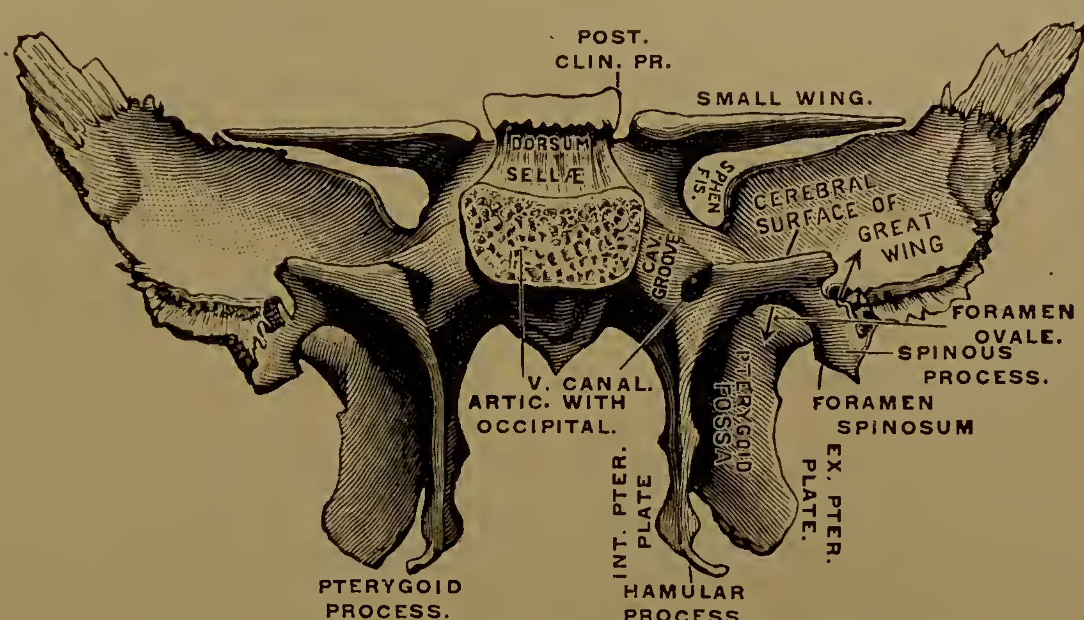


FIG. 218.—The sphenoid bone, viewed from behind. (Testut.)

the vomer, and in front with the sphenoidal process of the palate, the latter converting a groove beneath the base of the vaginal process into the *pterygo-palatine canal.* Posteriorly at the base of the internal plate is the small *pterygoid tubercle,* between which and the lingula is the Vidian canal, and below which is the shallow *scaphoid fossa,* in which the tensor palati muscle arises. The *posterior border* is prolonged below into the slender, *hamular* ("hook-like") *process,* grooved externally near its base for the passage of the tendon of the tensor palati muscle. It is often to be felt behind and internal to the last upper molar tooth. In front the two plates are joined above, and form a smooth triangular surface, which forms the back wall of the spheno-maxillary fossa, and presents superiorly the anterior orifice of the Vidian canal. Below, the two plates are separated in front by the *pterygoid notch,* which is occupied by the pyramidal process of the palate-bone. The cartilage of the Eustachian tube is attached and supported along the posterior and inner aspect of the upper part of the internal plate.

Articulations.—The sphenoid articulates with all the other bones of the cranium, which it binds firmly together, and with five of the facial bones—viz., two malar, two palate, and the vomer, and sometimes one or both superior maxillæ.

Varieties.—The ligaments normally connecting the clinoid processes may become ossified. The *foramen of Vesalius,* for an emissary vein, is sometimes present internal to the foramen ovale.

Ossification occurs in cartilage from twelve centres in two divisions, a pre- and a post-sphenoid, which join at the olivary eminence, and are distinct in many animals. The sphenoidal sinuses begin to hollow out the body in the sixth year, before which they are confined to the sphenoidal turbinate bones, which develop separately in cartilage.

THE ETHMOID BONE.

The *ethmoid* or *sieve-bone* (Figs. 219–221) is roughly cuboidal, and projects downward from the ethmoidal notch of the frontal bone between the orbits to form part of the orbits, nasal fossæ, and base of the cranium. It is very light, being largely composed of cavities bounded by thin walls. It consists of a vertical and a horizontal plate, and of two lateral masses, the last suspended from beneath the lateral portion of the horizontal plate on each side.

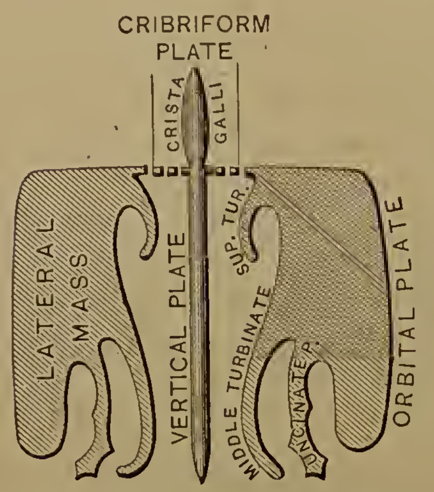


FIG. 219.—Diagram of the ethmoid bone in transverse, vertical section. (Testut.)

The *vertical plate* forms the upper third of the median (though often deflected) septum of the nose, and is grooved for the olfactory nerves. It projects into the cranial cavity above the horizontal plate as the median triangular *crista galli* (" crest of the cock "). This is most prominent in front, and along its thin posterior border it gives attachment to the falx cerebri. In front it divides into two lateral alæ, which articulate with the frontal, and usually complete the foramen cæcum. The vertical plate articulates in front with the nasal spine of the frontal and the crest of the nasal bones, below and in front with the triangular septal cartilage, below and behind with the vomer, and behind with the crest of the sphenoid.

The *horizontal* or *cribriform plate* is so named from a number of perforations arranged in three rows, of which those in the inner and outer rows are the larger and transmit the olfactory nerves to the inner and outer walls of the nasal fossæ. This plate forms the depressed *olfactory groove* of the anterior cranial fossa, which lodges the olfactory bulbs on either side of the crista galli. On each side of the fore part of the crista galli is a longitudinal slit for the nasal branch of the fifth nerve.

The *lateral masses* or *labyrinths* contain between their lateral and mesial walls a number of irregular, thin-walled *ethmoidal cells*. The thin, smooth, oblong *outer wall* forms most of the inner wall of the orbit, and is called the *os planum* (" smooth bone ") or *orbital plate*. The borders of this plate and of the lateral mass articulate in front with the lachrymal, below with the superior maxilla and palate-bones, behind with the sphenoid and sphenoidal turbinate bones, and above with the orbital plate of the frontal. The latter articulation completes the two horizontal, transverse grooves in each bone into the *anterior* and *posterior ethmoidal canals*. These articulations (together with that of the nasal process of the maxilla with the fore part of the lateral mass internally) close the exposed half-cells of the ethmoid. The *ethmoidal cells* are lined by a continuation of the nasal mucous membrane, and are divided by a transverse septum into an anterior and a posterior set. The anterior set opens into a sinuous canal, the *infundibulum*, which leads from the frontal sinuses to the middle meatus of the nose; the posterior cells open into the superior meatus. The cells are sometimes divided into posterior, middle, and anterior sets, the two latter opening together. The *inner wall* forms the upper part of the outer wall of the nasal fossa, and is grooved for olfactory nerves and blood-vessels. It consists of the *superior* and *middle turbinate bones*, which have attached upper borders, but are free and somewhat rolled outward inferiorly. They are continuous in front, but separated in the posterior half by a channel, the *superior meatus* of the nose, directed forward

om the posterior border. The middle turbinate extends the length of the bone, ıd overhangs and bounds superiorly the *middle meatus* of the nose. From beneath e fore part of the lateral mass in front of the os planum a long, thin lamina of ›ne, the *uncinate* ("hook-like") *process* projects downward and backward in the ıter wall of the middle meatus, where it articulates with the ethmoidal process ' the inferior turbinate bone, and helps to close the inner wall of the maxillary nus.

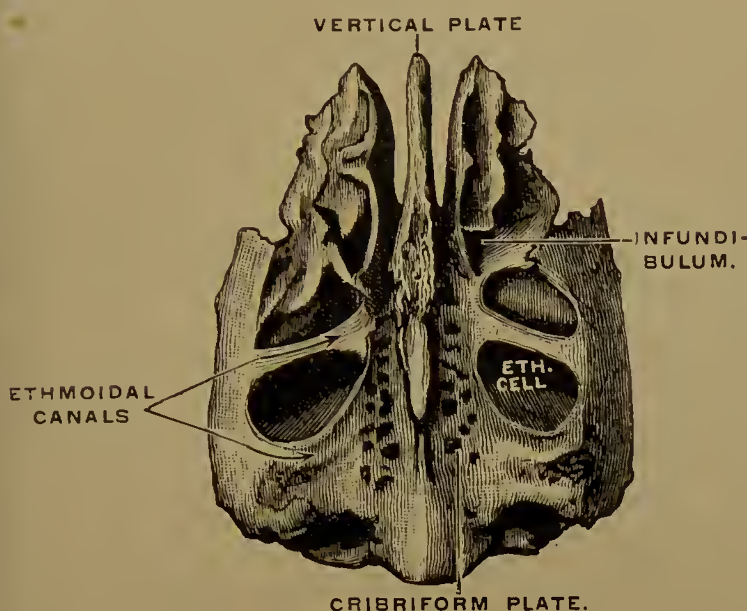


FIG. 220.—The ethmoid bone, seen from above. (Testut.)

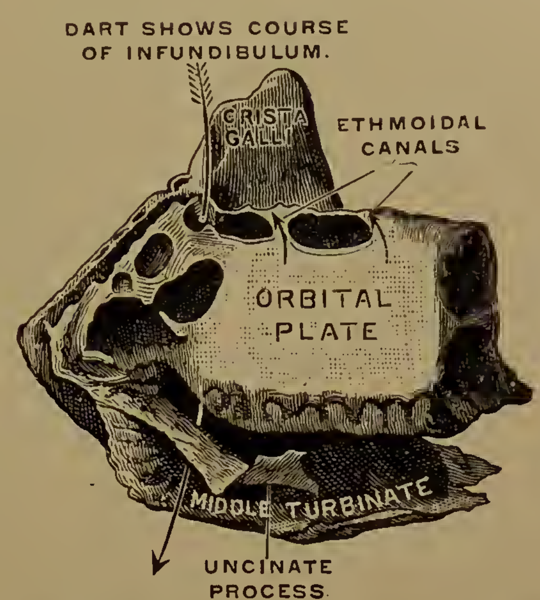


FIG. 221.—The ethmoid bone, its left side. (Testut.)

Articulation occurs with thirteen bones—viz., the frontal and sphenoid of the ·anium, and the vomer, two nasal, two lachrymal, two maxillæ, two palate, ıd two inferior turbinate bones of the face.

Ossification proceeds in cartilage from three centres—one in the perpendicular ate and one in each lateral mass. True bony ethmoidal cells do not appear ıtil the third year.

THE BONES OF THE FACE.

THE MAXILLA, OR SUPERIOR MAXILLARY BONE.

The *maxilla* or *upper jaw-bone* (Figs. 222–224) forms the largest part of the cial skeleton, including part of the floor and outer wall of the nasal fossa, the ›of of the mouth, and the floor of the orbits, and in it are lodged the upper teeth. : comprises a central hollow body and four processes. Its shape is characteristic ' man and of his food and the mode of employing it. Surgically, it is important om its many diseases.

The Body.—The *facial surface* looks forward and outward, and presents a rominent ridge, due to the fang of the canine tooth, which separates two shallow ›pressions, the *incisive fossa* in front and the *canine fossa* behind. Above the tter and just below the orbital margin is the *infraorbital foramen*, where the fraorbital nerve and artery emerge. The inner margin of this surface presents e deep *nasal notch*, giving attachment to the soft parts of the nose. The lower lge of the notch at its inner end is prolonged forward into the *anterior nasal ine*. The convex *posterior* or *zygomatic surface* is separated from the facial ırface by a ridge ascending from the socket of the first molar tooth to the malar ·ocess. This surface forms the anterior boundary of the zygomatic fossa, and upper and inner part bounds the spheno-maxillary fossa in front. Near its ntre are the apertures of the two or more *posterior dental canals* for nerves and ssels of that name. The prominent posterior inferior angle is the *tuberosity*, hich gives attachment to a few fibres of the internal pterygoid, and articulates ong its rough internal border with the tuberosity of the palate-bone. The *nasal internal surface* forms the outer wall of the nasal fossa in the lower and middle

meatuses, and presents in front a ridge, the *inferior turbinate crest,* which articulates with the inferior turbinate bone. Above and behind the surface is deficient, presenting the large irregular *opening into the antrum.* Above this opening there are one or two half cells, which complete as many ethmoidal cells. Behind it the surface is rough for articulation with the vertical plate of the palate-bone, except for a smooth groove directed downward and forward from the posterior border,

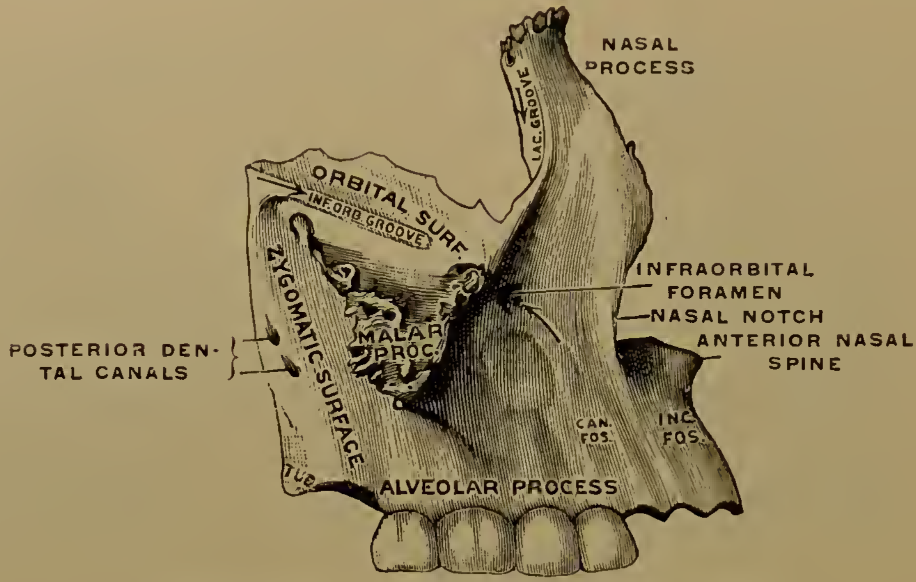


FIG. 222.—The right maxilla, outer surface. (Testut.)

which is completed by the palate-bone into the *posterior palatine canal.* The *posterior border* is separated from the pterygoid process of the sphenoid by the tuberosity of the palate-bone. Behind the nasal process and between it and this surface notice the *lachrymal groove,* which descends with a backward and a slight outward inclination. This groove is completed into a canal for the nasal duct by the lachrymal and inferior turbinate bones, and opens below into the inferior meatus. The smooth, triangular *orbital* or *upper surface* forms the floor of the orbit and the inner part of its lower margin. Internally it articulates from before backward

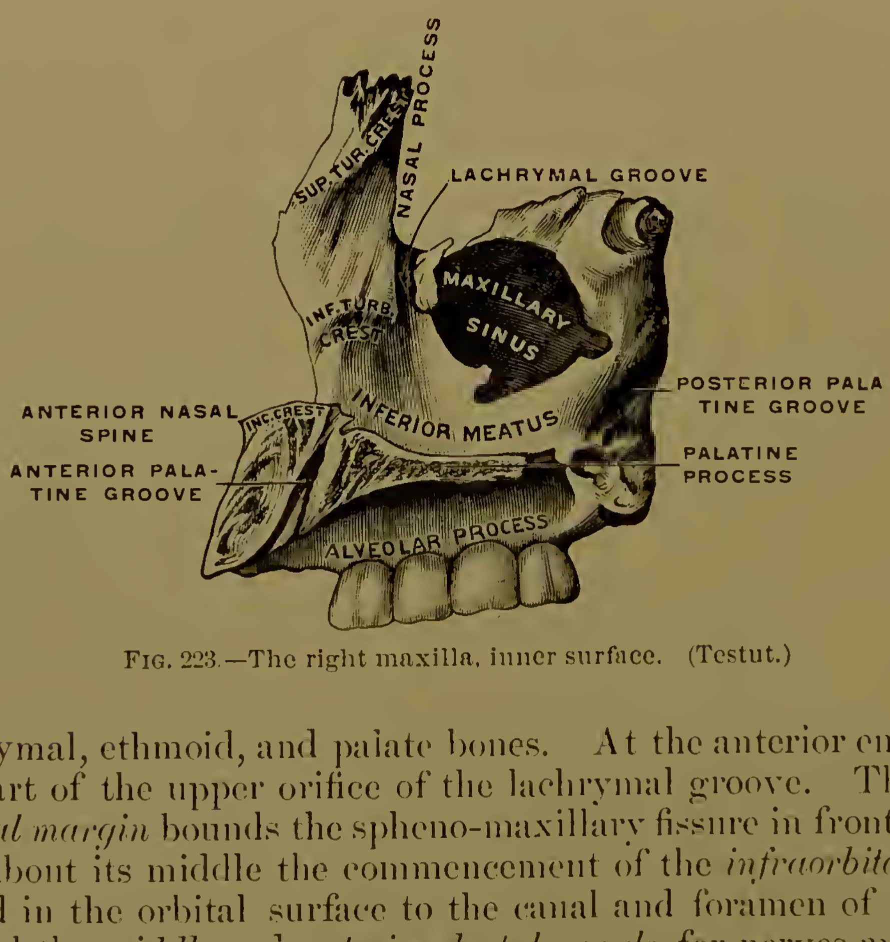


FIG. 223.—The right maxilla, inner surface. (Testut.)

with the lachrymal, ethmoid, and palate bones. At the anterior end of this border is the outer part of the upper orifice of the lachrymal groove. The free, smooth, *postero-external margin* bounds the spheno-maxillary fissure in front and internally, and presents about its middle the commencement of the *infraorbital groove,* which passes forward in the orbital surface to the canal and foramen of the same name. From the canal the *middle* and *anterior dental canals,* for nerves and vessels of the same name, run downward in the facial portion of the bone. The *antero-external*

margin of this surface bounds the rough upper surface of the thick triangular *malar process*, which articulates with the malar bone. This process is continuous in front with the facial surface and behind with the zygomatic surface of the body.

The *nasal process* is a triangular plate of bone which projects upward and slightly inward. It presents *externally* a smooth surface continuous with the facial surface of the body. The *internal surface* is crossed by the *superior turbinate crest*, which articulates with the middle turbinate bone. Above the crest it articulates with the ethmoid (closing its foremost cells), and below the crest this surface forms part of the outer nasal wall in the middle meatus. The serrated *summit* articulates with the frontal, the *anterior border* with the nasal, and the *posterior border* is marked by the lachrymal groove, which lodges the lachrymal sac. The sharp posterior border of this groove articulates with the lachrymal bone, while the smooth anterior border forms the inner margin of the orbit, the point of whose junction with the lower margin is marked by the *lachrymal tubercle*.

The *alveolar process* is the thick, arched lower border of the bone, which contains the *alveoli* ("little hollows") or tooth-sockets, corresponding in shape and number to the roots of the eight teeth which occupy them.

The *palate process*, projecting horizontally inward from the junction of the body and the alveolar process, articulates with its fellow of the opposite side to form the anterior three-fourths of the hard palate, the upper surface of which belongs to the floor of the nose, the lower to the roof of the mouth. Both surfaces are transversely concave; the upper is smooth, while the lower is rough and marked at its lateral margin with a groove for the vessels and nerves passing forward from the posterior palatine canal. The *posterior border* articulates with the horizontal plate of the palate-bone, which completes the hard palate, while the *median border* joins with its fellow to form, superiorly, the vertical *nasal crest*, which is grooved to receive the vomer. In front of the vomer this crest, suddenly becoming much higher, is called the *incisor crest*, which supports the septal cartilage of the nose, and ends in front in the anterior nasal spine. On each side of the nasal crest, where it joins the upper surface of the palate, is seen the *incisor* or *Stenson's foramen*, for the terminal branches of the posterior palatine arteries. These two foramina pass downward and forward, and, converging, open on the roof of the mouth as a single canal, the *anterior palatine fossa*, common to them and the two *foramina of Scarpa*, which are placed in front of and behind the former in the median suture, and transmit the naso-palatine nerves. In young bones the *premaxillary suture* extends from this fossa on each side to, but not through, the outer alveolar border, internal to the canine socket. The part in front of this suture on both sides represents the *premaxillary bone* of the lower animals, and includes the incisor teeth. It is separately formed, and sometimes remains separate from the maxilla on one or both sides in cases of cleft-palate.

FIG. 221.—The maxillary sinus and the inner wall of the orbit. The apex of the sinus and the outer wall of the orbit have been removed. (Testut.)

The *antrum of Highmore*, or *maxillary sinus*, is a pyramidal air-chamber occupying the body of the bone, and lined with mucous membrane. Its thin walls correspond to the surfaces of the body. The apex corresponds to the malar process, and the base to the nasal surface, the large opening in which is partly closed by the palate-bone behind, the inferior turbinate bone inferiorly, and the uncinate process of the ethmoid and the lachrymal above and in front. The opening, made still smaller by the mucous membrane, appears in the middle meatus of the nose as one or sometimes two apertures. Along the lower

angle the roots of the first two molars often project into the cavity. The antrum may sometimes be partly, rarely completely, subdivided.

Articulations.—The maxilla articulates with its fellow and with the nasal, frontal, lachrymal, ethmoid, palate, vomer, inferior turbinate, and malar bones, and sometimes with the sphenoid.

Ossification occurs early in membrane from four centres, and some of the lines between the parts are often to be seen in the young adult bone, especially in the floor of the orbit. The antrum appears in fœtal life.

THE PALATE-BONE.

The *palate-bone* (Figs. 225, 226) is L-shaped, and is wedged in between the maxilla and the pterygoid process of the sphenoid, forming the back part of the hard palate, of the lateral wall of the nose, and of the floor of the orbit. It has a horizontal and a vertical plate, united at a right angle. The tuberosity projects backward and outward from the rear of this angle, and the vertical plate is surmounted by two processes, the orbital and sphenoidal.

The **horizontal plate** completes the hard palate, and presents a smooth, concave *upper surface* and a rough *lower surface.* The latter presents behind a transverse ridge which gives attachment to the aponeurosis of the soft palate, connected with the tensor palati muscle. The *anterior border* articulates with the palate process of the maxilla; the *internal border* articulates with its fellow, forming the continuation of the nasal crest which supports the vomer, and ends at the posterior border in the *posterior nasal spine.* The free and sharp *posterior border* bounds the posterior nares inferiorly, and gives attachment to the soft palate.

The **vertical plate** is thin and presents a rough *outer surface,* which, applied against the maxilla, completes the groove near the posterior border of the latter

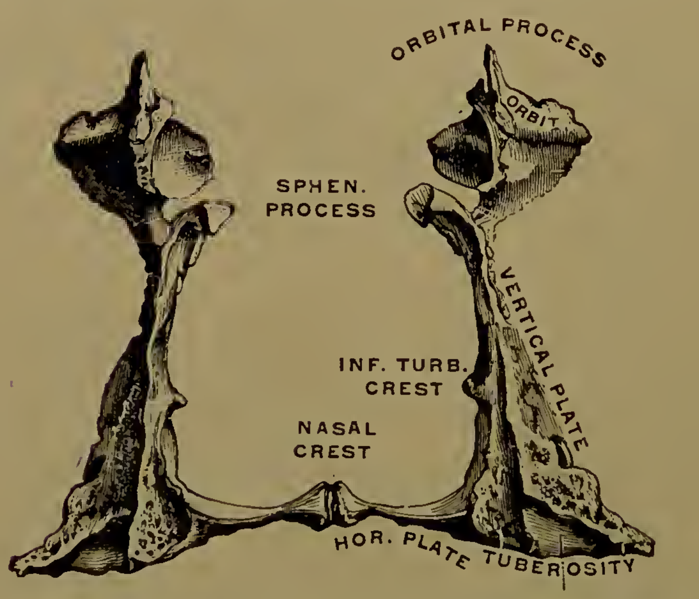


Fig. 225.—The two palate-bones in their natural position, dorsal view. (Testut.)

Fig. 226.—The right palate-bone, inner surface. (Testut.)

into the *posterior palatine canal* for the descending palatine nerve and vessels. Behind the groove is a smooth surface superiorly, forming part of the inner wall of the *spheno-maxillary fossa,* below which the surface is rough for articulation with the pterygoid process and the maxilla successively. In front this surface overlaps and narrows the opening of the antrum by a thin projection, the *maxillary process.* The *inner* or *nasal surface* presents the hind part of the inferior and middle meatuses of the nose, each limited above by a transverse ridge, the *turbinate crest,* articulating with the inferior and middle turbinate bones respectively. Above the upper ridge the two processes ascend, separated by the deep *spheno-palatine notch,* which is converted into a foramen of the same name by articulation with the sphenoid bone. This foramen connects the spheno-maxillary and nasal fossæ,

nd transmits the spheno-palatine artery and nerve. At the lower end of each rocess internally is a grooved surface entering into the superior meatus.

The five-sided *orbital process* surmounts the anterior border of the vertical late, and articulates with the maxilla in front, the sphenoid behind, and the thmoid internally. The ethmoidal cells or the sphenoidal sinus may extend into s hollow body. Of the two free surfaces the superior forms the rear angle of e orbital floor, and the external looks into the spheno-maxillary fossa, while the order between them bounds the spheno-maxillary fissure internally at its hind end.

The *sphenoidal process* curves upward and inward, and articulates externally nd superiorly with the base of the internal pterygoid plate and of the sphenoidal ody, completing with the former the pterygo-palatine canal. At its lower part, front, a small surface looks outward into the spheno-maxillary fossa. The ner surface looks into the nasal fossa, and above, where it touches the ala of he vomer, forms a part of its roof.

The *tuberosity* or *pyramidal process* is wedged in between the tuberosity of the naxilla and the pterygoid process. It presents externally a small free surface in he zygomatic fossa. Posteriorly it fills the pterygoid notch, and completes the terygoid fossa by a smooth triangular surface lying between two rough grooves, which articulate with the anterior borders of the two pterygoid plates. Inferiorly, ear its junction with the horizontal plate, with which it is continuous, are seen he lower orifices of the accessory, posterior, and external palatine canals.

Articulation.—The palate articulates with its fellow, the vomer, maxilla, infeior turbinate, sphenoid, and ethmoid.

Ossification proceeds from a single centre in the membrane of the nasal capsule.

THE VOMER.

The *vomer* ("ploughshare") (Fig. 227) is a thin, irregular quadrilateral plate orming the lower and back part of the nasal septum. It is usually deviated rom the vertical plane, most often to the left. Each *lateral surface* is covered vith muco-periosteum, and presents a faint groove running downward and forvard to conduct the naso-palatine nerve to Scarpa's canal. The thick *superior*

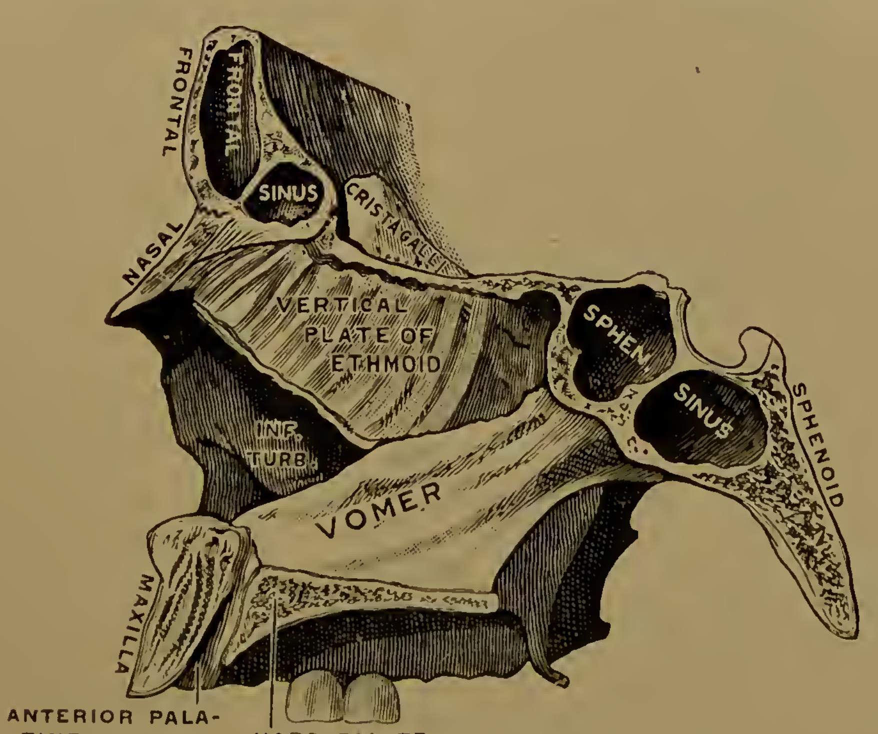


FIG. 227.—Sagittal section of face, a little to the left of the middle line, showing the vomer and its relations. (Testut.)

border splits into two *alæ* ("wings"), which embrace the rostrum of the sphenoid, while their margins meet the vaginal processes of the sphenoid and the sphenoidal processes of the palate-bones. The oblique *anterior border* joins the vertical plate of the ethmoid above, and below it is grooved for the septal cartilage. The *infe-*

rior border is received into the groove of the nasal crest of the maxillæ and palate-bones. The truncated *anterior angle* fits in behind the incisor crest of the maxillæ. The thin, free *posterior border* separates the two posterior nares.

Ossification proceeds from a single centre in membrane, and forms two lamellæ, which cause the absorption of the intervening cartilage.

THE INFERIOR TURBINATE BONE.

Each *inferior turbinate bone* (Figs. 228, 243) is a scroll-like lamella which separates the middle from the inferior meatus of the nasal fossa, and is attached above and externally to the outer wall of the nose, but is free below and internally. Its convex *inner surface*, marked by pits and longitudinal grooves for vessels, ends below in the convex, thickened *free border*, which is rolled upon itself. The attached *upper margin* articulates in front with the inferior turbinate crest of the maxilla, behind which it rises abruptly into the *lachrymal process*, which articulates with the lachrymal bone and helps to close the lachrymal canal. Behind this is the *maxillary process*, which is bent downward and closes the lower part of the opening into the antrum. Above and behind the latter process the *ethmoidal process* rises to join the uncinate process of the ethmoid. The posterior part of this margin is attached to the inferior turbinate crest of the palate-bone. The posterior *angle* is sharp, the anterior more blunt. The *outer surface* is concave and grooved.

FIG. 228.—Right inferior turbinate bone, external surface. (Testut.)

Ossification.—This bone ossifies from a single centre in cartilage, and may be regarded as a detached portion of the ethmoid.

THE NASAL BONE.

The two oblong *nasal bones* (Fig. 229) form the bridge of the nose. The *facial surface* of each is vertically concave above and convex below, and transversely convex. The *posterior* or *nasal surface*, transversely concave, is rough above, where it rests upon the nasal process of the frontal. Below it forms part of the roof of the nose, and presents a longitudinal groove for the nasal nerve. This groove ends in a small notch near the inner end of the thin *lower border*, which attaches the lateral nasal cartilage. The short, thick *upper border* articulates with the nasal notch of the frontal. The long *outer border* articulates with the nasal process of the maxilla. The *inner border*, thicker above, meets that of its fellow, with which it is prolonged backward into a median crest, which from above downward rests upon the nasal spine of the frontal, the vertical plate of the ethmoid, and the septal cartilage of the nose.


FIG. 229. — Nasal bones, viewed from before. (Testut.)

Ossification proceeds from a single centre in membrane overlying cartilage, which is absorbed. At birth the bone is relatively broad. The shape of the nose depends largely upon that of these bones.

THE LACHRYMAL BONE.

The *lachrymal bone* (*os unguis*), "nail-bone" (Figs. 230, 231), is a thin quadrilateral scale of bone forming the front of the inner wall of the orbit. Its *external* or *orbital surface* presents a larger, flat hind or *orbital part*, and a smaller grooved fore part, forming the *lachrymal sulcus* or *groove* for the lachrymal sac. These portions are separated by a sharp vertical ridge, the *lachrymal crest*, which is prolonged forward at its lower end into the *hamulus*, which often articulates with the lachrymal tubercle of the maxilla, and bounds the orifice of the lachrymal canal externally.

The *internal surface* closes some of the anterior ethmoidal cells above, and inferiorly looks into the middle meatus of the nose. The anterior border articulates with the nasal process of the maxilla, the superior with the internal angular process of the frontal, and the posterior with the orbital plate of the ethmoid.

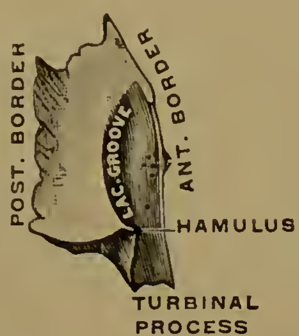


FIG. 230.—Right lachrymal bone, outer surface. (Testut.)

FIG. 231.—Right lachrymal bone, inner surface. (Testut.)

The inferior border behind the crest joins the orbital plate of the maxilla, and in front it is prolonged downward as the *descending* or *turbinal process*, which joins the lachrymal process of the inferior turbinate bone to complete the lachrymal canal.

The lachrymal *ossifies* from a single centre in membrane.

THE MALAR BONE.

The quadrangular *malar bone* (Figs. 232, 233) forms the prominence of the cheek and helps to separate the orbit from the temporal fossa. The *outer surface* is convex, and presents near its centre the orifice of the malar canal. The concave *inner surface* looks into the temporal fossa above, the zygomatic fossa below, and articulates in front by a rough triangular surface with the malar process of the maxilla. The four angles are directed vertically and horizontally. The promi-

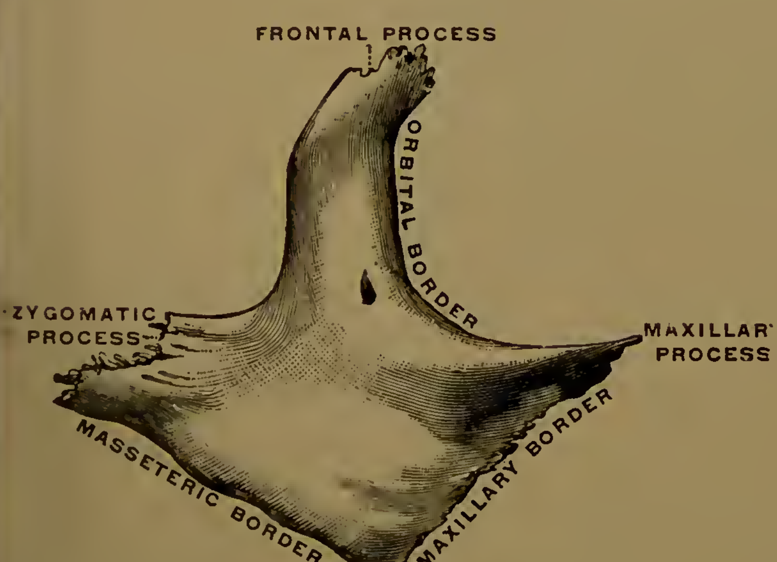


FIG. 232.—Right malar bone, outer surface. (Testut.)

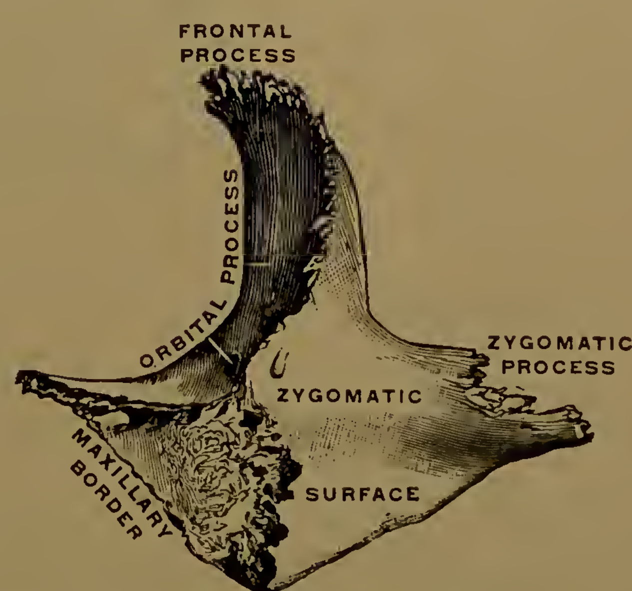


FIG. 233.—Right malar bone, inner surface. (Testut.)

nent, serrated *upper angle* or *frontal process* articulates with the external angular process of the frontal, and the *posterior angle* or *zygomatic process* is bevelled above, and articulates with the end of the zygoma. The sinuous *temporal border* between these two angles is continuous with the upper edge of the zygoma below and the temporal ridge above, and gives attachment to the temporal fascia. The *postero-inferior* or *masseteric border* completes the lower edge of the zygomatic arch and gives origin to some fibres of the masseter. The *antero-inferior* or *maxillary border*, the inferior angle, and the anterior angle or *maxillary process* articulate with the maxilla. The *antero-superior* or *orbital border* is curved to form the outer margin and the outer half of the lower margin of the orbit. From this border the curved, triangular *orbital process* projects backward and inward, and

forms the anterior boundary of the temporal fossa and the fore part of the outer wall and floor of the orbit. It articulates above with the frontal, and behind with the great wing of the sphenoid and the orbital plate of the maxilla. Between the articulations with the latter two bones there is usually a free margin bounding the spheno-maxillary fissure in front. The *temporal* and *malar canals*, for the temporo-malar branches of the fifth nerve, are seen on the orbital surface.

Ossification proceeds in membrane from two or sometimes three centres, and the adult bone is occasionally divided by a horizontal suture into two unequal parts.

THE MANDIBLE, OR INFERIOR MAXILLARY BONE.

The *lower jaw-bone* (Figs. 234, 235) is a large, strong, horseshoe-shaped bone, forming the lower third of the facial skeleton, and articulating by means of a pair of condyles with the glenoid fossæ of the temporal bones. It consists of a curved, nearly horizontal body in front and two vertical portions or rami behind.

The **body** consists of two symmetrical, lateral halves, whose *symphysis* ("together-growth") or union in the middle line is marked on the *external surface* by a faint vertical ridge which expands below into the triangular *mental protuberance* or chin. The centre of the base of the protuberance may be slightly depressed, and from its prominent lateral angles, or *mental* ("chin") *tubercles*, the rather faint *external oblique line* extends backward and upward to become con-

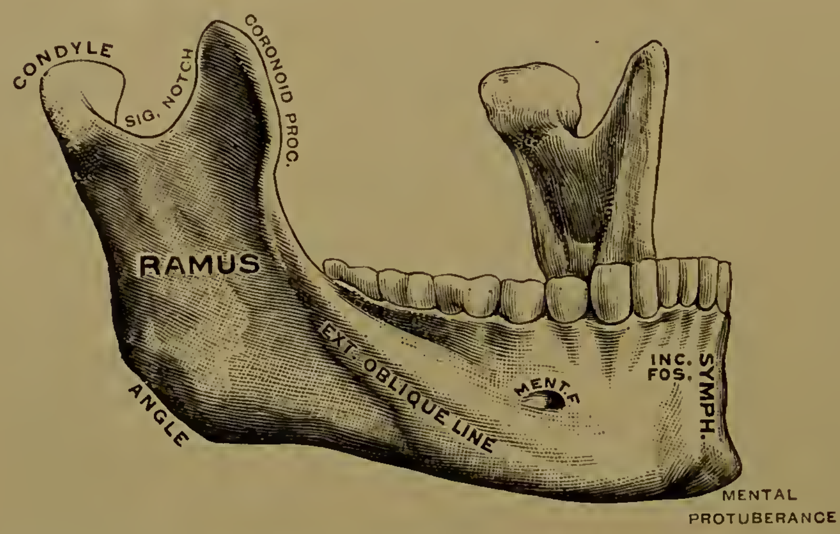


FIG. 234.—The mandible, viewed from the right and a little in front. (Testut.)

tinuous with the anterior border of the coronoid process. Below the incisor teeth on each side is the *incisor fossa*. Midway between the upper and lower borders and in line with the second bicuspid tooth, or the interval between the two bicuspids, is the *mental foramen*, transmitting the mental nerve and vessels from the dental canal. The *internal surface* presents at the symphysis, superiorly, a linear groove, ending below in a small foramen, below which are two pairs of *genial* ("chin") *tubercles*, sometimes fused into a single median ridge. The upper pair gives origin to the genio-hyoglossi muscles, and a small median ridge, from which the genio-hyoid muscles arise, usually takes the place of the lower pair. Below and on each side of this, and close to the lower border, is a rough depression for the insertion of the anterior belly of the digastric muscle. Beginning above the latter and at the side of the lower genial tubercle on each half of the bone, the *internal oblique line* or *mylo-hyoid ridge* passes backward and upward to the ramus. This gives origin to the mylo-hyoid muscle, and, at the posterior end, the superior constrictor muscle and the pterygo-maxillary ligament. Above the line, on each side of the symphysis, is the shallow *sublingual fossa* for the sublingual gland; and below it, at the side, is the *submaxillary fossa* for the submaxillary gland. The *superior* or *alveolar border* on each side presents the sockets for the roots of

ight teeth, and externally gives origin to the buccinator as far forward as the first molar. The *inferior border*, thick, smooth, and rounded, projects beyond the upper, and is grooved for the facial artery near its junction with the ramus.

The **ramus** is quadrilateral and thinner than the body. The masseter muscle is inserted on its *external surface*. On the *internal surface*, about its middle, is the *inferior dental foramen*, leading to the *inferior dental canal* for the inferior dental vessels and nerves. This canal is nearer the inner surface behind and the outer in front, where it connects with the mental foramen. It communicates by a series of fine channels with the bottom of each tooth-socket. The front and inner edge of the foramen is sharp and prominent, forming the *lingula* ("little tongue"), which gives attachment to the spheno-mandibular or long internal lateral ligament of the jaw. Behind the lingula and below the foramen the *mylo-hyoid groove* (sometimes a canal at first) starts in its downward and forward course beneath the mylo-hyoid ridge, and lodges the mylo-hyoid nerve and vessels. Between this groove and the angle the internal pterygoid muscle is inserted on a rough triangular space. The lower border, continuous with that of the body, meets the posterior border at the *angle* of the jaw. This is usually slightly everted, and gives attachment posteriorly to the stylo-mandibular fold of fascia. The sharp, concave upper border, known as the *sigmoid notch*, separates the two processes, and is crossed by the masseteric nerve and artery. The posterior process, or *condyle*, surmounts the

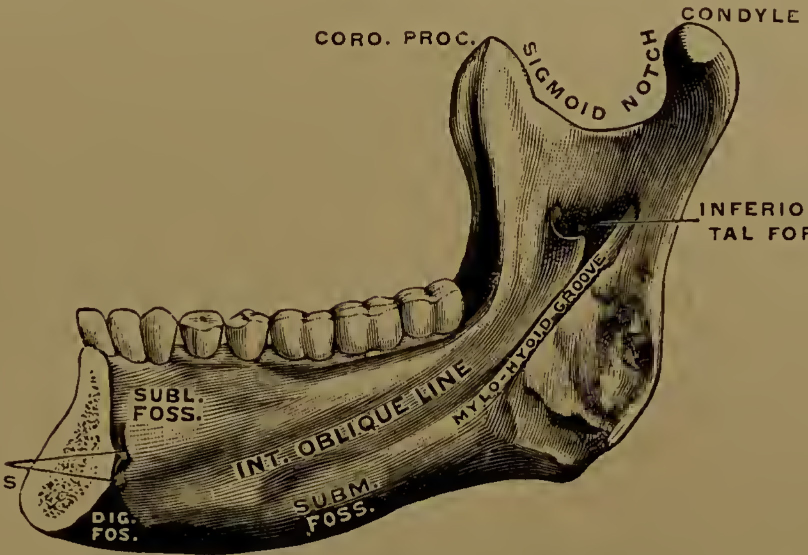


FIG. 235.—The right half of the mandible, inner surface. (Testut.)

posterior border on a constricted portion, or *neck*, on the front of which, internally, is a depression for the insertion of the external pterygoid muscle. The condyle is convex and transversely elongated on an axis which, prolonged, would meet that of its fellow near the front of the foramen magnum. Its prominent outer end, beyond the articular surface, forms a *tubercle*, to which the external lateral ligament is attached. The thin, *coronoid process* tapers upward and outward in front of the sigmoid notch, and to its tip, borders, and internal surface the temporal muscle is attached. Its anterior border is continuous with that of the ramus. The inner surface presents a ridge, continuous below with the internal oblique line and the inner alveolar edge. Between this ridge and the anterior border is a groove for the insertion of the temporal muscle above, and, for a short distance, for the buccinator below.

The *changes according to age* (Figs. 236, 237) are so ordered that the upper and lower gums, or teeth, as the case may be, meet in biting. Thus, at birth the angle between the body and ramus is about 175°, the body is shallow and consists mostly of alveolar process, and the mental foramen is near the lower border. At about four years of age, after the first dentition, the angle is reduced to 140°, as the body plus the teeth is much deeper. In adult life the depth of the body has so increased below, in the basal part, that the foramen is midway between the borders, and the angle is 120° to 110°, or even less. In old age the alveoli are absorbed, the foramen is near the upper border, the body is basilar, and the angle

is increased to 140° or so, thus allowing the gums to meet. Unless the angle between the ramus and the body is increased when the body is shallow, as in infancy or old age, only the fore part of the jaws would meet in mastication. The increase of this angle lessens the distance between the horizontal level of the condyles and that of the gums. Thus, in old age,

FIG. 236.—The mandible in infancy. (Testut.)

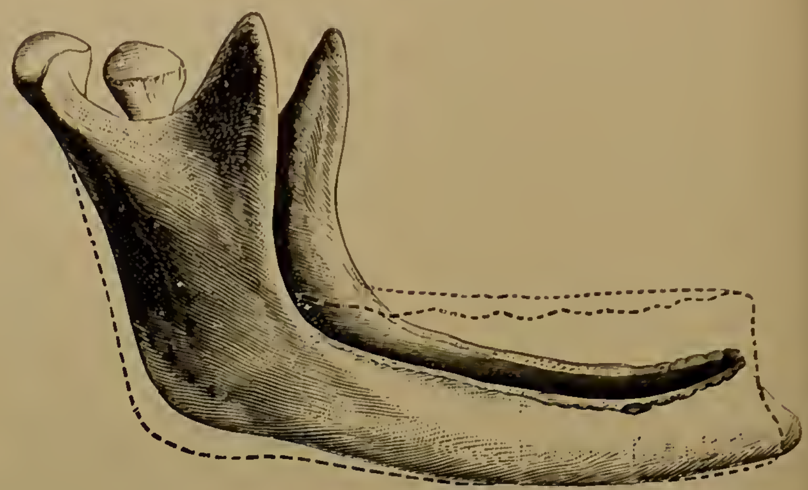


FIG. 237.—The mandible in old age. (Testut.)

the loss of the teeth and the absorption of the alveolar process lowers the level of the gums; and this level is raised, so as to reach that of the upper gums, by the increase or straightening out of this angle. This condition already exists in the infant, and, as the body of the jaw increases in height and the teeth are erupted, the angle is diminished so as to lower the level of the cutting edge of the lower teeth, and keep them in line with those of the upper jaw. This change continues until the jaw reaches its adult size. In old age the increase of this angle lengthens the jaw so that the chin protrudes, and this tightens the lips, which press back the upper border of the bone in front.

Ossification proceeds at a very early period from four to six centres on each side. The part from the symphysis to the mental foramen is ossified in the anterior end of Meckel's cartilage, the condyle and angle from separate centres in cartilage, and the rest in membrane. At birth the two halves are united by fibrous tissue.

THE HYOID BONE.

The *hyoid* ("like Greek letter upsilon") or *lingual bone* (Fig. 238) is a small U-shaped bone which may be felt at the base of the tongue, between the chin and the thyroid cartilage. It has a body and two pairs of cornua.

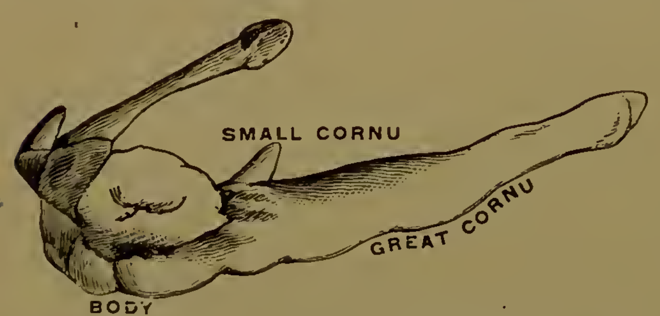


FIG. 238.—The hyoid bone, viewed from the left and in front. (F. H. G.)

The oblong *body* has a smooth, concave *posterior surface*, looking backward and downward toward the epiglottis. Its convex *anterior surface*, looking upward and forward, is divided by a transverse and sometimes a median vertical ridge into depressions for muscular attachment. The *superior border* gives attachment to the thyro-hyoid membrane.

The *great cornua* taper backward and upward from the sides of the body, ending in rounded tubercles to which the thyro-hyoid ligaments are attached. The cornua are flattened above and afford attachment to muscles. The *small cornua* are small conical pieces of bone, often partly, and sometimes wholly, cartilaginous, which project upward and backward from the junction of the great cornua and the body. Their extremities give attachment to the stylo-hyoid ligaments, which suspend the hyoid from the styloid processes of the temporal bones.

Ossification occurs in cartilage which lies in the second visceral arch and is continuous with the styloid process. There is a centre for each cornu, and for each half

the body. The synchondrosis of the great cornu with the body usually ossifies ter middle life. The synovial articulation of the small cornu seldom ankyloses.

THE SKULL AS A WHOLE.

The Sutures.

The *sutures* are the closely-fitted articulations of the uneven edges of the ones of the skull, in which the bones are separated by only a fibrous *suture mem-ane*, continuous with the periosteum and dura. In the two synchondroses of e jugular and basilar portions of the occipital bone, at the base of the skull, rtilage intervenes until it is ossified in adult life. The sutures allow the rapid rowth of the skull in early life, diminish shocks, and, by being alternately evelled on either side, bind the bones so firmly together that dislocation is ext to impossible. Many of them are often, but not always, obliterated by ssification in adult life. The time when this commences is very variable, but it sually begins where they last came together—*i. e.*, near the posterior, anterior, or ntero-lateral fontanelles.

Though the sutures are best named from the bones which form them, those round the parietal bones have received special names from their shape, direction, tc., as the *sagittal* (interparietal), the *coronal* (fronto-parietal), the *lambdoidal* occipito-parietal), and the *squamous* (squamo-parietal).

The **fontanelles** ("little springs") are unossified, membranous spaces which xist before, at, and for a time after birth at the angles of the parietal bone. Their existence and position are due to the fact that, while the bones are quadri-ateral, ossification proceeds radially or circularly, so that the angles are the last o ossify. The larger, diamond-shaped *anterior fontanelle* is an important land-nark at parturition. It serves for a safety-valve for the rapidly varying intra-ranial pressure of early infancy, and closes during the second year. The *anterior* and *posterior lateral fontanelles* are closed in fœtal life. The *posterior fontanelle* s often filled up before birth, but the bones are then movable upon each other, and the triangle formed by their margins may be felt as a landmark during par-urition. Wormian bones often assist in the closure of the lateral and posterior fontanelles.

Wormian bones are small, irregular ossicles from supernumerary ossific centres which are found in varying numbers in the sutures, especially in those about the parietal bones, and chiefly near the fontanelles. They are most numerous and largest in the lambdoid suture, but must be distinguished from the interparietal portion of the occipital bone when it exists as a separate bone. A small ossicle, the *epipteric* ("upon the wing") *bone*, is found in most skulls in each anterior lateral fontanelle up to the fifteenth year, after which it usually joins the great wing of the sphenoid.

The Exterior of the Skull.

The skull is bilaterally symmetrical. The **superior region** includes the smooth convex surface. It is covered by the occipito-frontalis muscle and aponeurosis and the scalp. It extends from the supraorbital margins in front to the superior curved lines of the occipital bone behind and between the superior temporal lines laterally. The skull, viewed from above, is broader behind than in front, and is oval in outline, with slight projections at the frontal and parietal eminences and at the occipital protuberance. At the meeting of the sagittal and coronal sutures is the *bregma*, at the site of the anterior fontanelle; and the *lambda* is where the sagittal and lamboid sutures meet, at the site of the posterior fontanelle. The occipital protuberance is known as the *inion* ("occiput"). Except in very broad skulls the zygomatic arches are visible from above.

The **lateral or temporal region** (Figs. 239, 240) presents the *temporal fossa*,

formed by the temporal, parietal, sphenoid, frontal, and malar bones, and occupied by the temporal muscle. The fossa is limited below by the zygomatic arch externally and the pterygoid ridge of the sphenoid internally. Above it is bounded by the *temporal ridge*, which, starting at the external angular process of the frontal bone, arches upward and backward, and then downward. Near the coronal suture it usually divides into a *superior* and an *inferior ridge*. The latter limits the origin of the temporal muscle, and is continuous behind with the supramastoid crest and the posterior root of the zygoma. The former, less constant and not as marked, gives attachment to the temporal fascia and arches down to the mastoid process near the *asterion* ("starry"), which is at the site of the posterior lateral fontanelle. The *pterion* ("wing"), at the site of the anterior lateral fontanelle, is where the parietal, frontal, sphenoid, and temporal bones come together. The temporal fossa communicates with the zygomatic fossa through the opening bounded externally by the zygomatic arch.

The *zygomatic fossa* is bounded in front by the zygomatic surface of the maxilla, internally by the external pterygoid plate, externally by the zygomatic arch

FIG. 239.—Skull, viewed from the left side, showing the principal craniometric points.

and ramus of the jaw, and superiorly by a small triangular surface on the squamosal and by the great wing of the sphenoid internal to the pterygoid ridge. Posteriorly it is limited by a line drawn from the sphenoidal spine to the tubercle on the anterior root of the zygoma. It is occupied by the pterygoid and temporal muscles and the coronoid process of the lower jaw. Internally, between its anterior and internal boundaries, is the vertical *pterygo-maxillary fissure*, between the maxilla and the anterior border of the external pterygoid plate. This connects the zygomatic with the *spheno-maxillary fossa*. Above and at right angles to the pterygo-maxillary fissure is the *spheno-maxillary fissure*, which connects the upper part of the zygomatic and of the spheno-maxillary fossæ with the orbit. This fissure lies nearly horizontally between the free margins of the orbital surfaces of the maxilla and the palate-bone internally and the sphenoid externally. In front the fissure is usually limited by the malar bone, though the maxilla and sphenoid may articulate here and exclude it.

The *spheno-maxillary fossa*, shaped like an inverted pyramid, is a small space

tween the maxilla and the root of the pterygoid process. It is bounded in ont by the upper and inner part of the zygomatic surface of the maxilla, ternally by the vertical plate and the orbital and sphenoidal processes of e palate-bone, behind by the roots of the pterygoid process and the lower rt of the anterior surface of the great wing of the sphenoid. The apex ads into the posterior palatine canal, the base into the back of the orbit rough the hind part of the spheno-maxillary fissure. Internally the sphenolatine foramen connects it with the nasal fossa, and behind are seen the foramen tundum, Vidian canal, and pterygo-palatine canal (in the order named, from ove and without, downward and inward.) The fossa contains Meckel's ganion, with its roots and branches, and the terminal branches of the internal axillary artery enclosed in a mass of fat.

The lateral region presents postero-inferiorly the external auditory meatus, early in the same vertical transverse plane with the bregma, and behind this e mastoid process, with the variable mastoid foramen behind and above it.

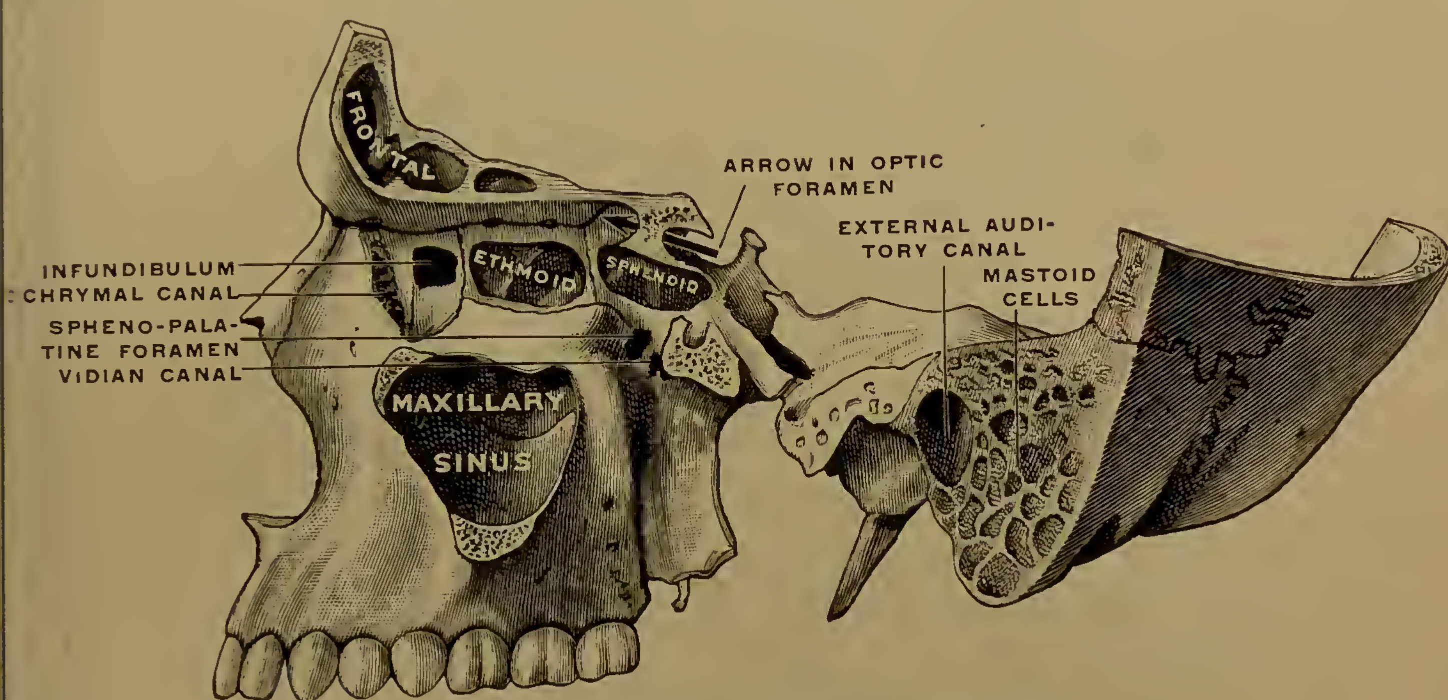


FIG. 240.—The bony sinuses of the head. (Testut.)

The **base of the skull externally** (Fig. 241) from the incisor teeth to the xternal occipital protuberance is very irregular, and may be studied in three ivisions.

The *anterior* or *palate division* includes the *hard palate*, formed by the palate rocesses of the maxillæ and the palate-bones, and bounded laterally and in front y the *alveolar arch*. Mesially in front notice the *anterior palatine fossa*, into vhich four foramina open, and from which, in young skulls, the suture separating he premaxillary bone runs to the outer side of each lateral incisor tooth. At the osterior angles are the lower openings of the *posterior palatine canals*, from each f which a groove runs forward in the angle between the palate and the alveolar rch for the anterior palatine nerve and the posterior palatine vessels. The *amular processes* are seen at the postero-lateral limits of the hard palate, behind nd internal to the last molar teeth. Between these and the posterior palatine anal are the openings of the accessory and external palatine canals.

The *middle* or *subcranial division* extends back to a line joining the tips of the nastoid processes. It slopes upward and forward from behind, and is at a higher evel than the anterior division. Between these two divisions are the following vertically-placed structures: Mesially are the *posterior nares*, separated by the omer, and bounded below by the horizontal plates of the palate-bones, laterally y the internal pterygoid plates, and above by the body of the sphenoid and the ile of the vomer. On each side is seen the *pterygoid fossa*, completed by the uberosity of the palate-bone below, and lodging the internal pterygoid and tensor alati muscles. The latter muscle arises from the *scaphoid fossa*, a subdivision

of the pterygoid fossa at its upper part. External to the pterygoid fossa is the *zygomatic fossa,* whose roof forms part of the base of the skull.

The basilar process of the occipital bone and a small part of the body of the sphenoid occupy the *median portion* of the middle division, while *laterally* are the petrosals and small portions of the great wings of the sphenoid, of the squamosals, and of the occipital bone. In the median line we notice the *pharyngeal tubercle* and the anterior margin of the *foramen magnum,* termed the *basion.* Laterally, we notice from before backward, in a nearly sagittal line, the *foramen ovale,* the *foramen spinosum,* the opening of the bony portion and the groove for the cartilaginous portion of the *Eustachian canal,* the entrance of the *carotid canal,*

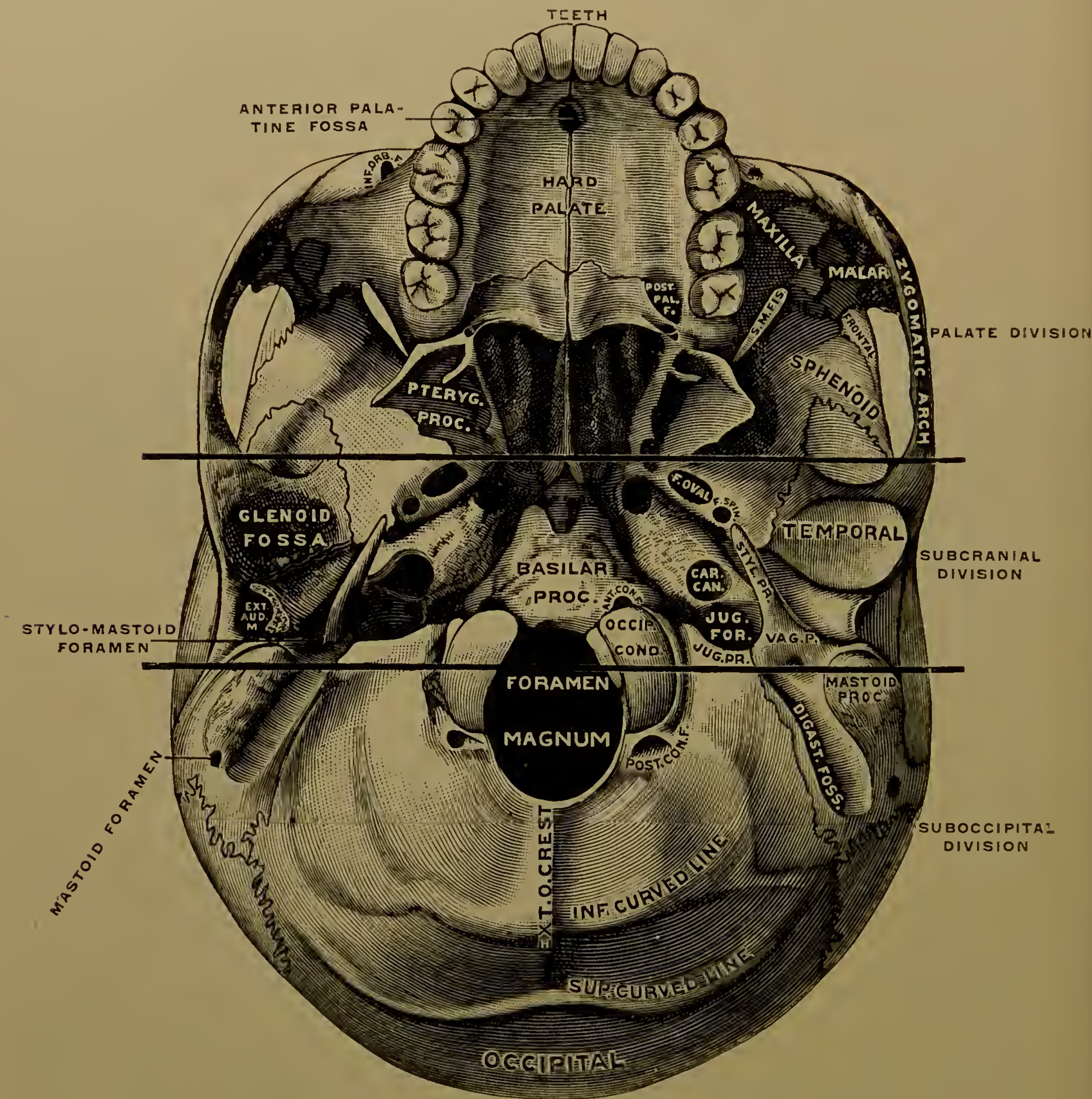


FIG. 241.—Base of the skull, viewed from below, the mandible having been removed. (Testut.)

and the *jugular fossa* and *foramen.* Internal to the latter is the *anterior condylar foramen,* and externally the *stylo-mastoid foramen.* Between the extremity of the petrous portion of the temporal bone, the basilar process of the occipital and the sphenoid, we notice the *foramen lacerum medium,* filled by fibro-cartilage in the recent state. In an oblique line from the mastoid process to the external pterygoid plate we find projecting the *styloid process,* the *vaginal process* of the tympanic bone, and the *spine of the sphenoid,* the latter at the inner end of the Glaserian fissure. On this surface is seen laterally the *eminentia articularis* in front of the articular part of the *glenoid fossa,* which is separted by the *Glaserian fissure* from the non-articular portion on the outer surface of the tympanic plate,

which lodges the parotid gland. The line limiting this region behind passes through the jugular processes of the occipital bone, and cuts the condyles a little behind their centre.

The *posterior* or *suboccipital division* extends back to the superior curved lines of the occipital bone, divided into two lateral halves by the external occipital crest. It includes, mainly, rough lines and intervening spaces for muscular attachment. Behind the condyles are the *posterior condylar fossæ* and *foramina* when the latter are present. Internal to and slightly behind the mastoid processes are the digastric and occipital grooves, for the digastric muscles and the occipital arteries respectively.

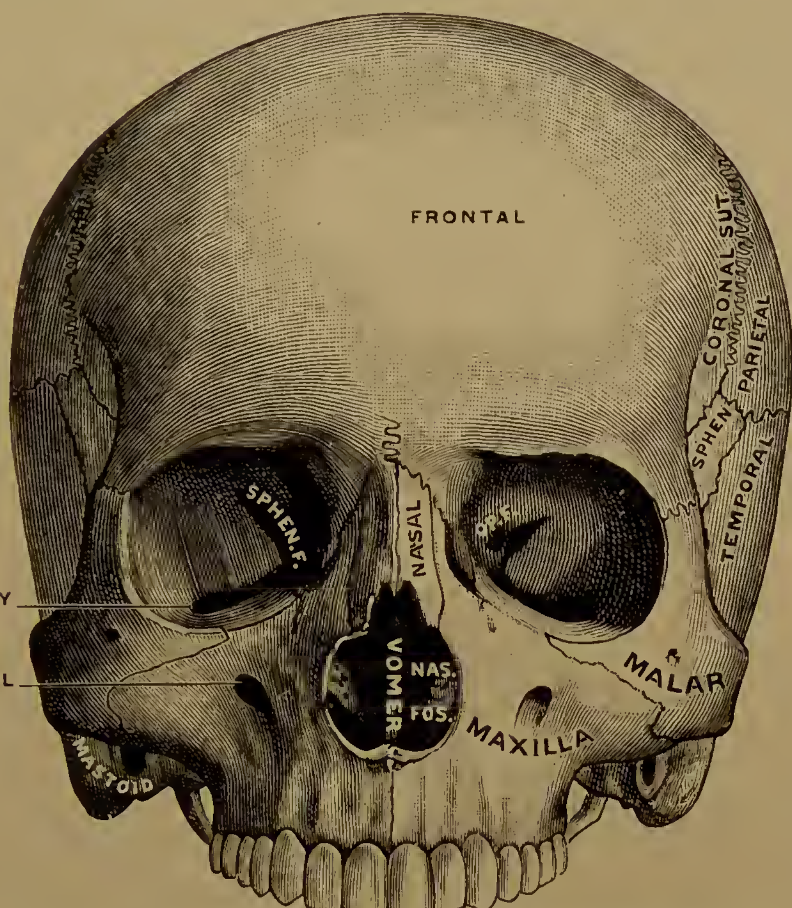


FIG. 242.—Front view of the skull, the mandible having been removed. (Testut.)

The **anterior or facial region** (Fig. 242) presents the *nasion*, in the centre of the naso-frontal suture, below the glabella. Below the nasion is the prominent *bridge of the nose*, formed by the nasal bones and the nasal processes of the maxillæ. Below this is the *anterior nasal aperture*, which is shaped like an inverted heart and is often unsymmetrical. Its thin margins attach the nasal cartilages, and its lower border projects forward as the *anterior nasal spine*. In the recent state it is bisected by the septal cartilages. Below this, on either side, are the incisor fossæ. On either side of the bridge of the nose are the *orbits*, below which are the *canine fossæ*, and external to the latter the prominences of the cheeks, formed by the malar bones. The *teeth* are a prominent feature of this region, and below them the body of the lower jaw completes the anterior surface. The three large *foramina*, *supraorbital*, *infraorbital*, and *mental*, each for a branch of one of the three divisions of the fifth nerve, lie in a nearly vertical line drawn through the second lower bicuspid tooth or the interval between the two lower bicuspids. The small malar canal is situated more laterally on the malar bone.

The **orbits** are two irregularly quadrilateral, pyramidal fossæ which lodge the eyeballs and their muscles, nerves, and vessels. The *base* of each, directed forward and slightly outward, is formed by the *orbital margin*, which is quadrilateral in shape with rounded angles. It is bounded above by the frontal, with the supraorbital notch or foramen at the junction of its inner and middle thirds; internally by the nasal process of the maxilla; below by the infraorbital margins of the maxilla and malar, and externally by the malar bone. The concave *roof* of each orbit is formed by the orbital plate of the frontal and the small wing of

the sphenoid. The *outer walls* of the orbits diverge so as to be almost at right angles with each other, and are formed by the orbital surfaces of the great wings of the sphenoid and the malar bones, the latter containing the temporal and malar canals. The *floor*, sloping from within downward and outward, is formed by the maxilla, with the orbital process of the palate-bone behind and a small part of the malar bone in front. The *inner walls* of the two cavities are nearly parallel, and are so continuous with the floors as to give a triangular shape to the orbit in some specimens, which is especially marked at birth. Each is formed, from before backward, by the nasal process of the maxilla, the lachrymal bone, the os planum of the ethmoid, and the body of the sphenoid. The *apex* of the orbit is at the inner extremity of the sphenoidal fissure, whose outer end separates the back part of the roof and outer wall. The *optic foramen* lies at the back of the orbital roof, above and internal to the apex. In the angle between the roof and the inner wall lie the anterior and posterior ethmoidal foramina in the ethmoidal section of the *transverse suture*. The latter extends horizontally between the external angular processes of the frontal bone, along the margins of the orbital plates and the nasal notch of the frontal. In the angle between the roof and the outer wall, in front, is the *fossa for the lachrymal gland*. In the angle between the outer wall and the floor in its posterior two-thirds is the *spheno-maxillary fissure*, communicating behind with the spheno-maxillary fossa, and in front with the zygomatic fossa. From its inner border the *infraorbital groove* passes forward in the floor of the orbit to the *infraorbital canal*. In the angle between the floor and the inner wall, and just behind the orbital margin, the *lachrymal groove* passes down into the *lachrymal canal*. A depression, sometimes a tubercle, for the pulley of the superior oblique muscle is seen a little behind the supero-internal angle of the orbital margin. The orbits communicate with the cranial cavity and the nasal, spheno-maxillary, and zygomatic fossæ.

The **nasal fossæ** (Fig. 243) are two irregular, oblong cavities of a truncated pyramidal shape. They are narrow transversely, especially above, but have a considerable diameter vertically and from before backward. They extend from the base of the skull to the upper surface of the hard palate, and open in front by the anterior nasal aperture, and behind into the pharynx by the posterior nares. They are situated one on each side of a median, vertical *septum nasi* or *internal wall*, formed by the vertical plate of the ethmoid, the vomer, the rostrum of the sphenoid, the nasal spine of the frontal, and the crests of the nasal, max-

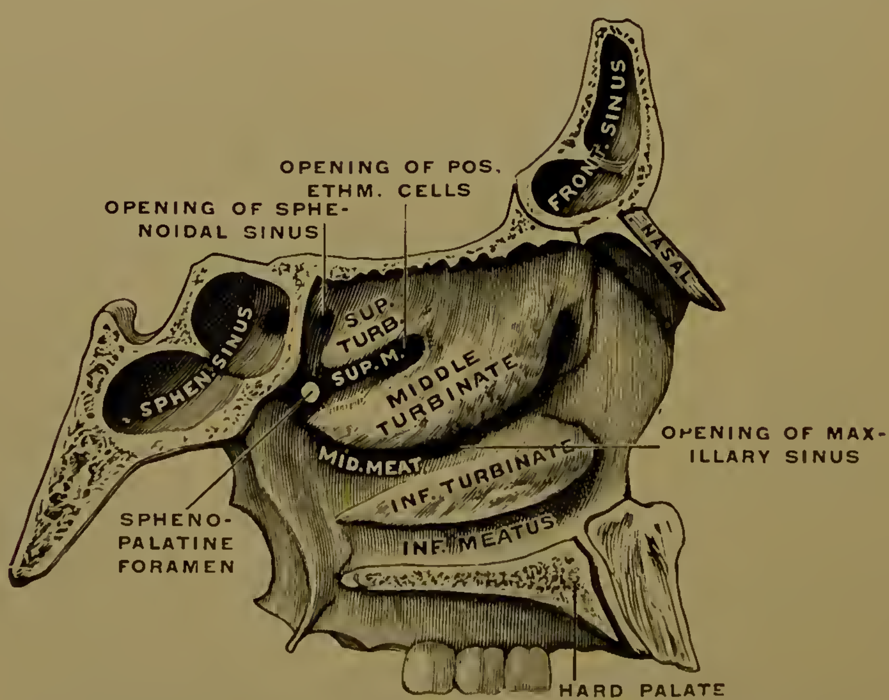


FIG. 243.—The nasal fossæ, viewed from the middle line. (Testut.)

illary, and palate bones. The angular interval in front between the vomer and the ethmoid plate is filled by the septal cartilage, which with the bony septum is

ually deflected to one side, most commonly to the left. The narrow *roof* of each ssa has a middle *horizontal part* formed by the cribriform plate of the ethmoid, th its many small apertures leading from the anterior cranial fossa, and an terior and a posterior part sloping downward. The anterior slope is formed the nasal bones and the nasal spine of the frontal. The posterior slope is med by the body of the sphenoid and the sphenoidal turbinate bones, and ntains the openings of the sphenoidal sinuses. The *floor* of each fossa, wider an the roof, is smooth and concave transversely, with a slight backward slope. is formed by the palate processes of the maxilla and palate-bone, and presents front, close to the septum, the *incisor foramen* (or *canal*), leading to the oral vity. The extensive *outer wall*, sloped downward and outward, is formed by e nasal, maxillary, lachrymal, ethmoid, inferior turbinate, and palate bones, and e inner surface of the internal pterygoid plate. It presents three horizontal cesses or *meatuses*, overhung by three *turbinate plates*, of which the upper two long to the ethmoid, and the lower is the inferior turbinate bone.

The *superior meatus*, between the superior and inferior turbinate plates of the nmoid (superior and middle turbinate bones), is very short, being limited to the sterior half of the fossa. It opens behind only, and into it open the posterior nmoidal cells and the spheno-palatine foramen, which connects it with the heno-maxillary fossa. The *middle meatus*, between the inferior turbinate plate the ethmoid (middle turbinate bone), and the inferior turbinate bone, is longer an the former. It opens both in front and behind, and into it open the maxillary nus or antrum, and, by means of the infundibulum, the frontal sinus and the terior ethmoidal cells. The *inferior meatus*, the longest and widest, also opens oth in front and behind, and lies between the inferior turbinate bone and the oor of the nasal fossa. The nasal duct opens into it superiorly in front and nnects it with the orbit. The nasal fossæ thus communicate by narrow passages ith all the neighboring fossæ and air-sinuses. The latter are hollow spaces ithin the maxilla, sphenoid, ethmoid, and frontal, already described in connection ith those bones. With the exception of the antrum, which exists during fœtal e, they originate during childhood, and all increase in size rapidly at puberty, nd more slowly throughout adult life.

The Interior of the Cranium.

In a skull bisected horizontally or vertically notice the great proportionate ze of the brain-cavity and the thickness and composition of its *walls* (Fig. 244). he latter consists of an *outer* and an *inner table* of compact bone and the intervening cancellous *diploë* ("fold"). The *inner table*, called the *vitreous table* from s hardness and brittleness, has a smooth, shining surface, marked with impressions for the convolutions of the brain and with grooves for blood-vessels. The kull-cap or *calvaria* averages one-fifth of an inch in thickness, but along certain dges, and especially at the base, the thickness is much greater. Thinner areas cist in the cribriform plate of the ethmoid and the orbital plates of the frontal one, where there is no diploë, and also in the lower occipital fossæ, and the quamous portions and glenoid fossæ of the temporal bones.

The **calvaria** or **skull-cap** consists of a vaulted dome, formed by the frontal nd parietal bones and the interparietal portion of the occipital bone. Its inner urface presents in the median line the *groove* for the *superior longitudinal sinus*, nding in front on the *frontal crest*, and behind at the *internal occipital protuberance*. On either side of the groove are varying numbers of *depressions for Pacchionian bodies*. This surface is marked by shallow cerebral impressions and rooves for meningeal vessels. The *parietal foramen*, for an emissary vein, is ound, when present, at the side of the longitudinal groove near the postero-uperior angle of the parietal bone.

The **base** or **floor of the cranial cavity** (Fig. 245) presents three irregular fossæ, rmed anterior, middle, and posterior.

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The *anterior fossa*, on a higher level than the rest of the cranial floor, supports the frontal lobes of the cerebrum, and is formed by the orbital plates of the frontal bone, the cribriform plate of the ethmoid, and the small wings and part of the body of the sphenoid. Over the orbits it is convex, but mesially it is depressed into the olfactory grooves for the olfactory bulbs on either side of the crista galli. In front of the crista is the foramen cæcum. The floor of the olfactory grooves presents numerous apertures in the cribriform plate for the olfactory nerves, mesially the slit-like foramen through which the nasal nerve passes into the nose, and laterally the internal openings of the anterior and posterior ethmoidal canals.

The *middle fossa*, on a lower level than the anterior, presents a central isthmus and two lateral depressed parts. The small median part is limited behind by the dorsum sellæ, and in front by the anterior margin of the optic groove. It lodges the pituitary body and the optic commissure, and presents laterally the grooves

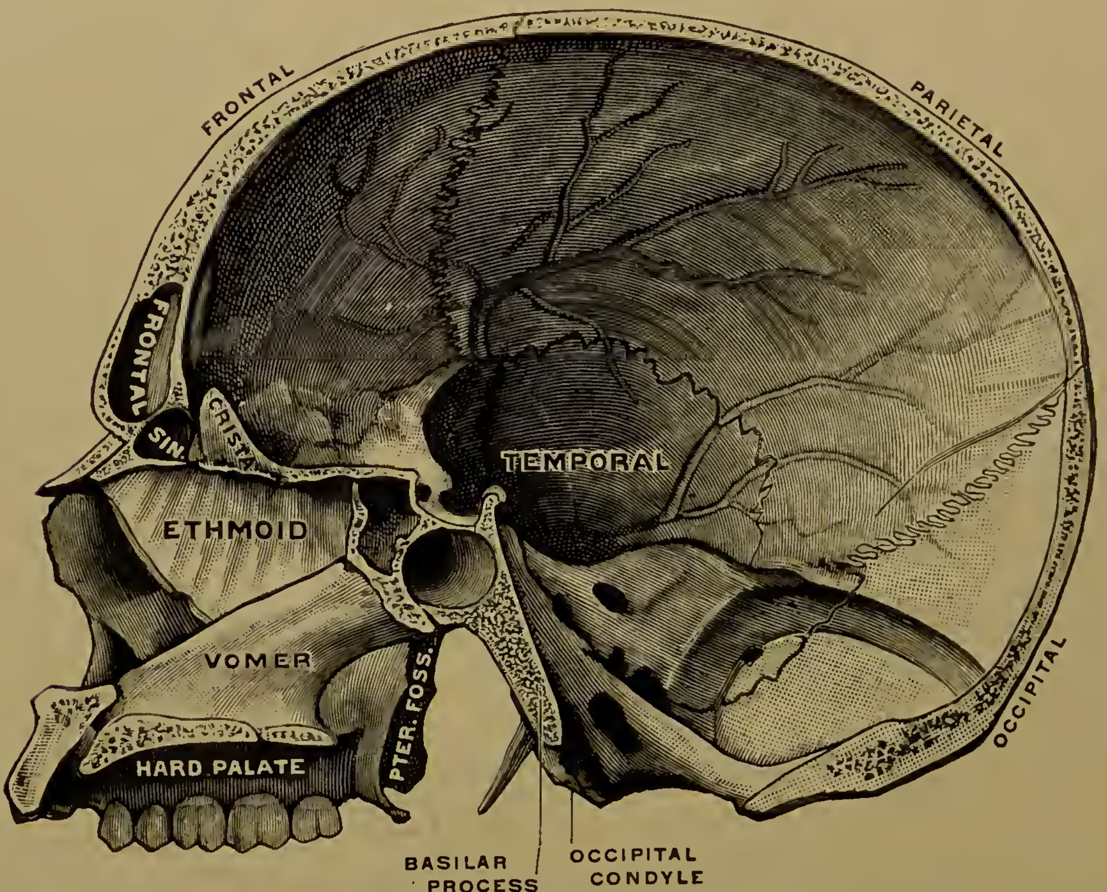

FIG. 244.—Sagittal section of skull, a little to the left of the middle line, the inner surface of the right half. (Testut.)

for the carotid arteries from the foramina lacera media forward to the optic foramina. The lateral part on each side is limited behind by the superior border of the petrous portion of the temporal bone, and in front by the free margin of the small wing of the sphenoid. It is formed by the great wing of the sphenoid and the squamous portion and the anterior surface of the petrous portion of the temporal. It lodges the temporal lobe of the cerebrum, and presents the following foramina from before backward: the *sphenoidal fissure* leading into the orbit; the *foramen rotundum*, leading into the spheno-maxillary fossa; the *foramen ovale* and the *foramen spinosum*, leading into the zygomatic fossa; the *foramen lacerum medium*, through which the carotid artery and plexus enter the cranial cavity; and the *hiatus Fallopii*. Grooves for the middle meningeal artery pass from the foramen spinosum outward, upward, and backward on the great wing of the sphenoid, the squamous portion of the temporal, and the parietal bone.

The *posterior fossa*, the deepest and largest, lodges the cerebellum, medulla oblongata, and pons, and is formed by the occipital bone, the petrous and mastoid portions of the temporal, the postero-inferior angle of the parietal, and the body of the sphenoid. Its anterior limits are the posterior limits of the middle fossa.

nd its posterior limits the grooves for the lateral sinuses whose limiting ridges ve attachment to the tentorium cerebelli. The *foramen magnum* occupies the entre, and external to it from within outward are seen the *anterior condylar foramen*, the *jugular foramen*, and the *internal auditory meatus*. Behind the jugular oramen is the opening of the *posterior condylar foramen* when present, and more xternally, in the sigmoid sulcus, is the more constant *mastoid foramen*. The rooves for the lateral sinuses pass outward from the internal occipital protuberance, usually cross the posterior inferior angle of the parietal bone, and thence end sinuously downward and inward on the mastoid portion of the temporal one, and onto the occipital bone, where they curve forward and end at the poste-

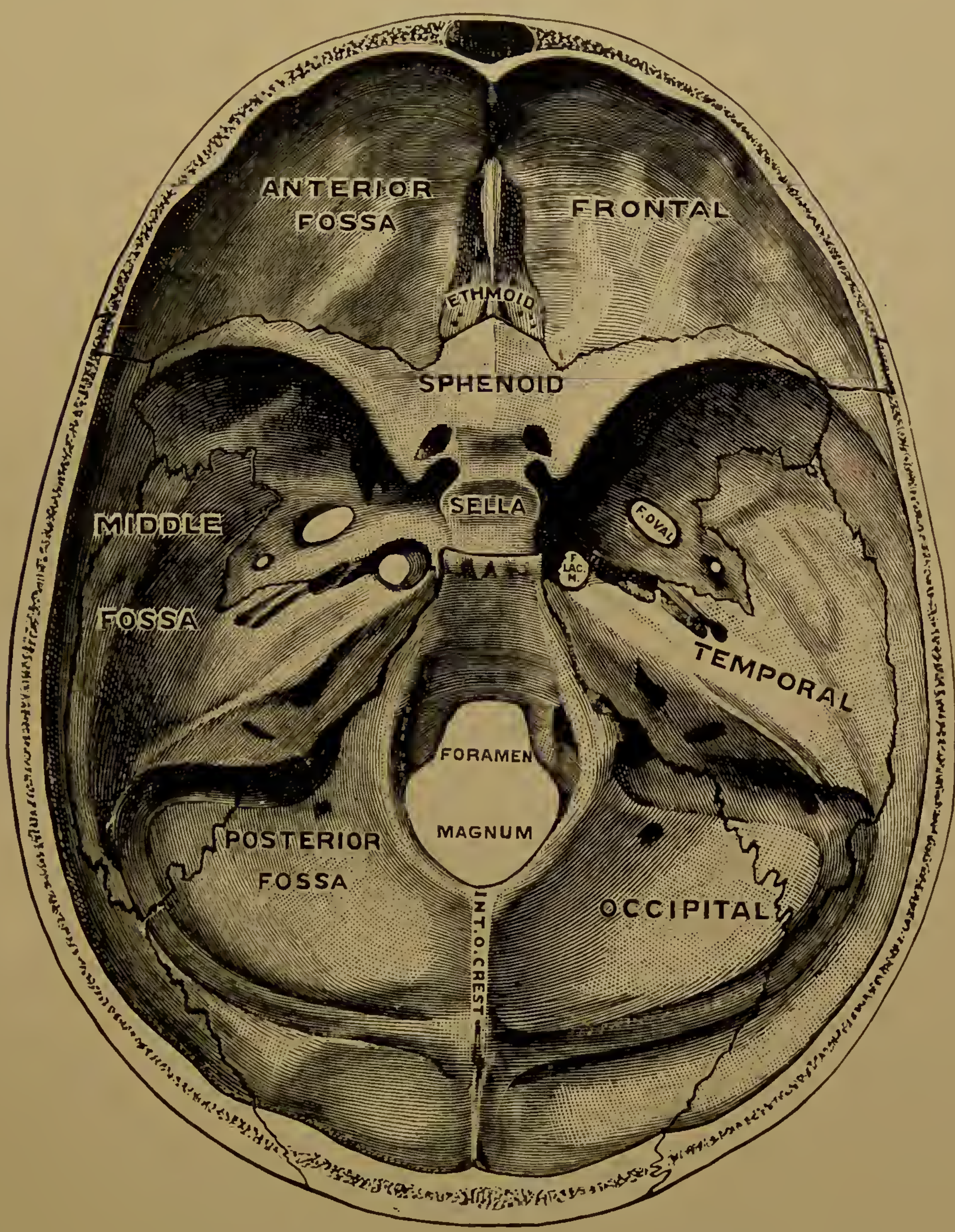

FIG. 245.—Base of the cranium, inner surface. (Testut.)

rior division of the jugular foramina. The grooves for the inferior petrosal sinuses lie along the suture between the petrous portion of the temporal bone and the occipital, and end in the anterior division of the jugular foramina. The *jugular foramen* (foramen lacerum posterius) is usually unsymmetrical on the two sides and of a somewhat pyriform shape. It is often divided into three compartments by two more or less marked constrictions. Through the largest and most posterior of these the lateral sinus passes into the internal jugular vein, and a small meningeal branch of the ascending pharyngeal artery ascends; the middle compartment transmits the glosso-pharyngeal, vagus, and spinal accessory nerves, and the anterior (sometimes completely separated) transmits the inferior petrosal sinus.

General Morphology of the Skull.

The cranial nerves pass through the skull in foramina occupying sutures or indicating points of union of two or more ossific centres. The foramen rotundum is the only exception to this rule in the skull, and this is probably a separated segment of the sphenoidal fissure. The division into primary foramina, or those where the nerves pass through the dura (or original brain-case), and secondary foramina, which are bony tunnels or canals not found in simpler skulls, though interesting, is not of sufficient importance for further description here. The remarkable constancy of the relation of the nerve foramina to the osseous elements has, with other facts, led to the conception of the vertebrate theory of the skull, which supposes that the skull is made up of a series of altered vertebræ, the neural arches of which have become greatly expanded to enclose the brain. Among the facts leading to this theory is the *apparent construction of the skull in three parts:* 1, the *central* or *basilar*, prolonging forward the vertebral axis around and beyond the end of the notochord in the *cranio-facial axis*[1]; 2, the *superior arches*, three[2] in number, enclosing the brain; 3, an equal number of *inferior arches*[3] surrounding the visceral cavity, as represented by the nose, mouth, and pharynx. But, although from analogy we may imagine that the primitive human skull was segmented like the vertebral axis, there is no evidence of this, and for a number of other reasons the division of the head into vertebral segments is untrustworthy and fanciful.

In the *development of the skull* three stages may be recognized: 1, the *membranous stage*, in which the brain is enclosed in a membrane representing the dura of the adult; 2, the *chondral stage*, in which the base and lower parts of the sides of the brain-case become cartilaginous, leaving the sides and roof membranous; 3, the *osseous stage*, in which both cartilage and membrane become ossified from a large number of ossific centres, which first appear in the membrane. Along the sides and in front sense-capsules become invaginated, and indent the skull-wall in the ears, eyes, and nose. Some of the bones of the skull are developed wholly, others partly, in the basal cartilage and its forward prolongation, the cartilaginous nasal capsule, or in the cartilaginous visceral arches; while some are developed wholly, others partly, in the membrane of the cranial vault, in that around the nasal capsule (forming the greater part of the upper face), and in that connected with the visceral arches.

The *human skull*, as compared with the skulls of lower vertebrates, is characterized by—1, its enormous brain-space and the corresponding expansion of the bones of the cranial vault; 2, the proportionally smaller development of the face, and especially of the jaws (bringing the face under the front of the cranium); 3, its being balanced and supported on the vertebral column (adapting it to the erect position) by a sudden bend in the vertebro-cranial axis, and a great posterior development of the cranium, bringing the occipito-vertebral articulation at the centre of gravity of the skull; 4, the downward opening of the nostrils and the diminished size of the nasal fossæ, bringing the orbits nearer together, so as to be nearly parallel internally and to look forward. The bones of the human skull are more completely consolidated, so that the total number is less than in the lower vertebrates. Thus the pre- and post-sphenoids, the interparietals, the squamosals, the styloids, the pterygoids, and the premaxillæ are often separate bones, and the frontal bone and mandible are frequently divided into two halves in vertebrate skulls.

[1] This is drawn from the basion to the anterior extremity of the sphenoid, and thence to the end of the anterior nasal spine (subnasal point), forming an angle, the *cranio-facial angle*.

[2] These consist of—1, the squamosal part of the occipital bone; 2, the great wings of the sphenoid, the squamosals of the temporal bones, and the parietals; 3, the small wings of the sphenoid and the frontal bone.

[3] These include in the first arch the pterygoids, the palate, and the maxillary bones; in the second, the mandible, the spheno-mandibular ligament, and the malleus of the ear; in the third, the styloid process, the hyoid bone, and the stylo-hyoid ligaments, plus the incus, and perhaps part of the malleus of the ear.

The Various Forms of the Skull.

The *skull at birth* is characterized by the small size of the face and the very large size of the cranium, the smallness of the base, the prominence of the parietal and frontal eminences, the absence of the mastoid processes, the diploë, the suture serrations, the impressions, grooves, and ridges, and by the existence of the fontanelles. The temporal squama and the great wings of the sphenoid do not extend far upward, and the glenoid fossæ are quite flat and small.

Variations with Age.—The skull grows very rapidly during the first seven years. *During the first dentition* the fontanelles close, the face enlarges, the jaws lengthen, and the zygoma projects. *By the seventh year* some parts, such as the circumference of the foramen magnum, the petrous portion of the temporal bones, the body of the sphenoid, and the cribiform plate, have attained their definitive size, while other parts are quite immature. *Near the approach of puberty* a second period of active growth begins, and results in the elongation of the face, due to the increased height of the nasal fossæ, the expansion of the air-sinuses, the enlarged teeth of the second dentition, and the augmented height of the alveolar arches of the jaws. Ossification becomes completed, and the adult shape and size are attained. The capacity of the cranium increases but little after thirteen years of age. In *later years* the muscular crests develop, the frontal region elongates, and the air-passages and cells expand, the latter process continuing in old age. In *old age* the skull undergoes atrophy, becoming thinner, lighter, and often a little smaller by absorption on the outer surface. The air-cells expand as the capacity diminishes, the face becomes smaller by absorption of the alveolar processes and the loss of the teeth, and the increase of the angle causes the lower jaw to project at the chin.

Sexual Variations.—The *male skull* is larger, heavier, and of greater capacity (11 : 10), especially in the frontal and occipital regions, than the female, and the ridges, occipital protuberance, mastoid processes, zygomatic arches, and frontal sinuses are more developed. The *female skull* preserves a look of immaturity in the smaller proportion of the face, the narrower and less prominent jaws, the prominence of the parietal eminences, and the smoothness of the surface.

Race differences, except among three or more large general classes, are often so slight, taking averages, as to require accurate and uniform cranial measurement or craniometry for their determination. Of the measurements the most important are the following, with the data of the average European skulls for each : (1) The *capacity*, 1450 c.c., affording a convenient indication of the development of the brain. (2) The *circumference*, 52 cm., taken in a plane passing behind through the *occipital point* (or the point of the occipital bone in the median plane farthest removed from the glabella), and in front through the *ophryon* (or the middle of the line drawn across the narrowest part of the forehead). (3) The *length*, 17 cm., from the ophryon to the occipital point. This is above the frontal sinus, and gives the length of the brain-case only, while the *maximum length* is between the glabella and the occipital point. (4) The *maximum breadth* is the greatest breadth between the parietals; the breadth at the level of the zygomata is 12.5 cm. (5) The *height* from the basion to the bregma is nearly the same as the breadth. The *cranio-facial angle* is about 96°. For the ready comparison of race-measurements the breadth and height are reduced to indexes by comparison with the length as follows : $\frac{100 \times \text{breadth or height}}{\text{length}}$. Furthermore, the shape of the transverse arch of the cranium, the fusion or complexity of the sutures, the degree of projection of the jaws (indicating an approach to, or a removal from, the animal type), the relation between the height and the width of the anterior nasal aperture (or nasal index), and of the base of the orbits (or orbital index), are subject to variation among different races. The *facial angle* (of Cloquet), which helps to determine the relative development of the face and the frontal part of the cranium, is that formed by two lines

meeting in the median line at the alveolar border of the maxilla, and drawn, one from the most prominent median frontal point and the other from the middle of the external auditory meatus. Several other measurements for more accurate determination of the form of the cranium are in use, for which Broca's or other works on craniology should be consulted.

The *situation and direction of the foramen magnum* differ greatly in man and the lower animals, and to some extent among the different races of man. In quadrupeds it is placed dorsally and looks backward, in man at or near the centre of the base, and looks downward and slightly forward in the European, downward and slightly backward in the negro; while in the anthropoid apes it is intermediate in position and direction as compared with that in man and the quadrupeds.

The most frequent *irregularity of form* is want of symmetry, which is usually present to a slight degree. Asymmetry usually depends upon premature synostosis or closure of one or more sutures, preventing growth in a direction at right angles to the line of that suture, and tending to increase the growth in other directions. Artificial pressure applied in early life may also cause irregularity of form, as seen in the case of the Flat-headed Indians.

THE ARTICULATIONS.

By GEORGE WOOLSEY.

THE *articulations*, or *joints*, are the connections existing between contiguous parts of the recent human skeleton. Softer substances intervene between the ends of the bones, and a fibrous capsule, with or without accessory ligaments, binds them together.

The articular surfaces, or ends of the bones, which are expanded in the case of long bones, are coated by a layer of connective tissue, or hyaline, or white fibro-cartilage. When hyaline cartilage is present as *articular cartilage*, its free surfaces are very smooth, so as to minimize friction, and it serves to diminish jars by its elasticity. It is thickest where the pressure is the greatest. The white fibro-cartilage occurs as *connecting fibro-cartilage* in the discs between the vertebræ and in the symphysis pubis; as *interarticular fibro-cartilage* in the plates in the temporo-mandibular and sterno-clavicular joints, and in the menisci in the knee-joint; and as *marginal fibro-cartilage* in the shoulder and hip-joints, where it deepens the sockets. The interarticular fibro-cartilages partly or completely divide the joint into two halves; they adjust dissimilar bony surfaces, increase the motion and security, and act as buffers to break shock. Connective tissue exists between contiguous bones of the skull as *suture membrane*.

The *ligaments*, which are the principal objects of study in this section, are strong, inextensible, but pliant bands of white fibrous tissue, continuous with the periosteum of the bones they unite. They occur in the shape of a more or less perfect *capsule*, usually reinforced where there is the most strain by external accessory bands or ligaments derived from intermuscular septa, modified tendons, or regressed muscles.

In joints moving on many axes the entire capsule and surrounding muscles are nearly uniformly strong; in those moving on one axis the lateral parts of the capsule are strengthened and designated as lateral ligaments. In some cases ligaments are formed of yellow fibrous tissue, as the ligamenta subflava, which unite parts not in contact.

The deep surface of the capsule is lined by the *synovial membrane*, which extends to, but not over, the articular cartilage. In the shape of folds or fringes it frequently projects into the joint-cavity, especially near the margin of the cartilage, where, often padded with fat, it fills up the interstices between the bones. This part of the membrane is highly vascular and liable to become villous and pedunculated, in which case it may cause pain by being pinched between the joint-surfaces. It secretes a thick, glairy fluid called *synovia*, which lubricates the joint. The synovial cavity sometimes communicates with bursæ and vaginal synovial membranes in the neighborhood of a joint.

Embryologically, a joint is formed from the tissue between the adjacent parts of the skeleton. This embryonic tissue may become the fibrous tissue of the suture membrane where the bones are developed in membrane, as in most of the bones of the skull; or it may become the thicker fibro-cartilage of the intervertebral discs, symphysis pubis, etc., where the bones are developed in cartilage. A partial synovial membrane may occur in this intervening cartilage. In more movable joints the synovial sac is more extensive, and the fibro-cartilage is inter-

articular, separating two synovial sacs, as in the sterno-clavicular joint, etc. These plates of fibro-cartilage may be perforated, or form merely a meniscus, attached to the inner surface of the capsule, as in the knee, or they may be wanting altogether, as in most of the more movable joints.

In accordance with these various differences, articulations are more or less movable. The classification of joints now employed is largely physiological, depending upon the degree and kind of motion.

Kinds of Joints.

A. **Synarthrosis** is the primary form of articulation, and includes those *immovable joints* (1) in which the contact of the adjacent surfaces is prevented only by a thin layer of fibrous tissue, continuous with the periosteum, as in many of the bones of the head; and (2) those where bone and cartilage are directly united, as in the case of the first rib and sternum, etc. Nearly all of this class are liable to bony union at different periods in advanced life, and in early life permit interstitial growth. In the skull these articulations are called *sutures,* of which we distinguish three varieties.

True sutures include *serrated* and *dentated sutures,* where the margins are interlocked, as in the sagittal and lambdoid sutures, respectively.

False sutures include *harmonic sutures,* where there is simple apposition, as between the two halves of the palate, and *squamous sutures,* where bevelled edges overlap one another, as in the squamo-parietal suture.

Grooved suture, or *schindylesis,* is where an edge of one bone fits into a groove in another, as in the case of the rostrum of the sphenoid and the vomer.

Synchondrosis is generally a temporary form of joint, where the thin layer of cartilage between the bones usually ossifies before adult life, as in the union between the epiphysis and shaft of long bones, and between the sphenoid and occipital bones.

B. **Amphiarthrosis** applies to joints which permit of slight movement, and include *symphysis,* where the opposed surfaces are united by a disc or plate of white fibro-cartilage, as between the bodies of the vertebræ or the pubic bones; and *syndesmosis,* where an interosseous ligament unites the surfaces, as in the lower tibio-fibular articulation.

C. **Diarthrosis** applies to the more perfect and movable joints containing synovial cavities. The capsule of these joints is lined by synovial membrane, secreting synovia, which serves for the lubrication of the joint. The bones are bound together by fibrous ligaments, forming more or less perfect capsules, which, tightened in some positions of the bones, relaxed in others, are often chiefly controllers of movement, while the surrounding muscles, aided by atmospheric pressure, hold the bones together. The following varieties are distinguished:

Arthrodia, or *gliding joints,* admit of but a limited amount of gliding motion, in one or more directions, between two nearly flat articular surfaces, as in the carpus and tarsus, and between the articular processes of the vertebræ.

Ginglymus, or *hinge-joints,* allow only movements of flexion and extension on one axis, between the cylindrical or trochlear convex and concave surfaces, as in the elbow and ankle.

Condyloid joints present spheroidal articular surfaces, which allow abduction, adduction, and circumduction, besides flexion and extension, as in the metacarpo- and metatarso-phalangeal articulations.

Saddle joints allow the same motions as condyloid. The surfaces are reciprocally saddle-shaped; hence they are sometimes called joints by *reciprocal reception.* The carpo-metacarpal joint of the thumb is an example.

Ball-and-socket joints (*enarthrosis*) permit movement in every direction between the spherical head and socket, as in the shoulder and hip. They are the most movable of joints.

Trochoides, diarthrosis rotatoria, lateral ginglymus, or *pivot joint* is a joint etween a pivot and a ring, as in the radio-ulnar and atlanto-axial articulations, hich allows only of rotation.

Kinds of Movement.

The various kinds of movement depend on the shape of the articulating surces, and are limited by the connecting ligaments and to a less extent by the urrounding soft parts. The different kinds of movement are often combined nd merged into one another in one joint.

Rotation is the movement of a bone about some longitudinal axis, often its wn axis, without much change of position.

Angular movement increases or decreases the angle between two bones. When is movement takes place around a transverse axis, it is called *flexion* and *extenon,* according as the angle is diminished or increased. When it takes place oward or from the median plane of the body, the middle finger of the hand, or e second toe of the foot, it is called *adduction* and *abduction* respectively.

Circumduction is a combination of the four angular movements, so that the oving bone describes a cone-like figure, with the apex at the joint, the base at s distal end.

Gliding is the simplest form of movement, and consists of a simple sliding or isplacement without marked angular or rotatory motion. It is common to nearly l diarthrodial joints, and is the only movement between the plane surfaces of thrmedian joints.

Morphologically, many ligaments are formed by the metamorphosis or regreson of muscles, due to loss of function, or by the migration of muscles, or by the egeneration of osseous and cartilaginous tissue. This is shown by a comparative udy of vertebrate ligaments, muscles, and bones. Atavistic examples are occaonally met with in the human subject.

The ligaments are never strained by muscles tending to pull the bones apart, or, on the contrary, the action of the muscles braces the bones firmly together. Iany long muscles passing over two or more joints co-ordinate their movements, nd so economize power. Some long muscles act as elastic ligaments, often iffusing the movement produced by the short muscles over more than one joint. Two or more joints are sometimes combined, and thereby increase their strength, ecurity, and variety of motions, as in the wrist and ankle.

THE ARTICULATIONS OF THE TRUNK AND HEAD.

1. The Articulations of the Vertebral Column.

There are two sets of articulations between the movable vertebræ—those etween the bodies and those between the articular processes. These parts are onnected together by ligaments; but *intermediate ligaments,* not connecting parts n contact, help to limit the movements of the spine and to complete the spinal anal.

The **Articulations between the Bodies of the Vertebræ** (Figs. 246, 250) are *mphiarthrodial.* The following ligaments bind them together:

The *intervertebral discs* are tough, elastic, but compressible plates, which are laced between and firmly unite the vertebral bodies from the axis to the coccyx; ut in the sacrum and coccyx they are ossified on the surface or throughout. They are firmly attached to the opposed surfaces of the bodies, these surfaces eing covered by a thin layer of cartilage, except near their margins. Their hape and size are the same as those of the surfaces of the bodies they connect. They are thinnest between the second and third cervical (the weakest spot in the ervical column), and thickest and largest in the lumbar region. In the cervical nd lumbar regions they are thicker in front than behind, and thus cause the

convexity forward in the former, and increase that in the latter, region. Those in the thoracic region are thicker behind, if anywhere, and so increase its curve. They form in the aggregate one-quarter of the length of the movable part of the vertebral column, which assumes a single curve, concave in front, the *curve of old age*, if the discs are removed or dried up. In structure the discs are made up of two parts. The *external* or *laminar portion* forms more than half the

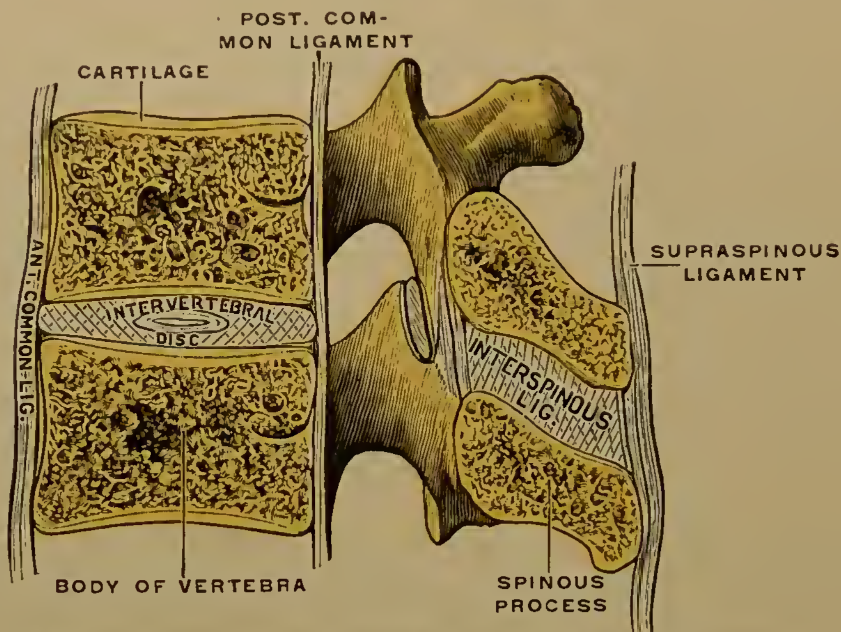

FIG. 246.—Two lumbar vertebræ in sagittal section. (Testut.)

mass, and consists of concentric layers of fibrous tissue with more and more cartilage-cells toward the centre. The fibres pass obliquely between the vertebræ and in the reversed direction in adjoining layers. Some layers are found only in front, making this part of the disc thicker, so that the *central* or *pulpy portion* is situated a little behind the centre. The latter is a yellowish, elastic, ball-like mass, composed of a fine fibrous matrix, imbedded in which is a net-work of angular, branching cells, more numerous toward the centre. It is a remnant of the notochord. On section of the disc through the pulpy portion the latter bulges out above the rest, showing that it is compressed by the laminar portion, so that it forms, as it were, a ball or pivot upon which the vertebral bodies move. A synovial cavity is described by Luschka in each central pulpy portion. The intervertebral discs are surrounded on all sides by a sheath of fibrous ligaments, incomplete laterally where the thin and more or less scattered fibres reach from one bone to the next, and are sometimes called the *lateral* or *short vertebral ligaments*.

The *anterior common ligament* is the strong band on the front of the bodies of the vertebræ. It extends from the under surface of the occipital bone, in the median line in front of the foramen magnum, to the front of the sacrum, reappearing below as the *anterior sacro-coccygeal ligament*. Above it is narrow and cord-like, and forms the thickened central portion of the *anterior occipito-atlantal* and of the *anterior atlanto-axial ligaments*. Below this it becomes broader as it descends. Of its fibres, which are dense, well-marked, and longitudinal, the superficial pass over several, the deep only between adjacent vertebræ. The fibres are attached to the intervertebral discs and to the edges of the vertebral bodies, and bridge over the median depressions of their ventral surface, thus rendering this surface more even. It limits extension.

The *posterior common ligament* extends along the dorsal surface of the bodies of the vertebræ within the spinal canal from the basilar groove of the occipital bone to the coccyx. Its upper end, often bilaminar, forms the *posterior occipito-axial ligament* between the axis and occipital bone. It is broad and even in the neck, extending completely across the vertebral bodies, narrower and dentated below. The broad dentations are at its attachment to the discs and margins of the vertebræ, and between them are the narrowed portions, separated from the backs of the bodies by venous plexuses. The superficial fibres extend over several

·tebræ, the deep between adjacent ones. Its smooth, shining, dorsal surface is ›arated from the dura by loose connective tissue except at the foramen magnum, ere the dura is adherent to it. It limits flexion.

The **Joints between the Articular Processes** are arthrodial or gliding joints. ıey are provided with synovial cavities, enclosed by capsular ligaments, which ː loosest in the neck, strongest and tighter in the lumbar region, and tightest in e thoracic region. In the neck the inner part of the capsule is formed by the ıstic tissue of the ligamenta subflava, which form more and more of the capsule the thoracic and lumbar regions.

Intermediate Ligaments Uniting the Neural Arches.—The *ligamenta subflava*, mposed of yellow fibrous tissue, connect the laminæ of adjacent vertebræ from e axis to the sacrum. In the upper two spaces they are continued, with less, no, elastic tissue, under special names. Superiorly they are attached to the ·ntral surface of the laminæ, above their lower borders, and inferiorly to ·e upper borders and the adjacent parts of the dorsal surfaces. They become icker and stronger below, and are best seen from in front. Laterally they e continuous with, and form part of, the ·psular ligaments, reaching as far as the tervertebral foramina; mesially the lateral .ılves unite beneath the roots of the spines, ɔm which point the *interspinous ligaments* ex- nd back as membranous bands between the ljacent borders of the spines. These are ·st marked in the lumbar region, where the ›res extend from the root of one spine to the ɔ of the one next above. In the cervical gion they are replaced by the interspinales uscles. They extend dorsally to the *supra- ›inous ligaments*, which form a continuous ›rd along the tips of the spines from the ›ine of the seventh cervical vertebra to ıe coccyx, covering the lower end of the cral canal. They consist of longitudinal ɔres, of which the deep fibres connect the ·ps of adjacent spines, and the superficial ·ıss over several. Above they are continued · the external occipital protuberance as the *ɡamentum nuchæ* (Fig. 246), from which a ıin median septum passes forward to be at- ıched to the occipital crest and the cervical ›ines. In the lower animals the nape liga- ıent is strong and elastic, and supports the ead; in man it is of mixed white and yellow fibrous tissue in structure, and ›rms a median intermuscular septum of no great importance.

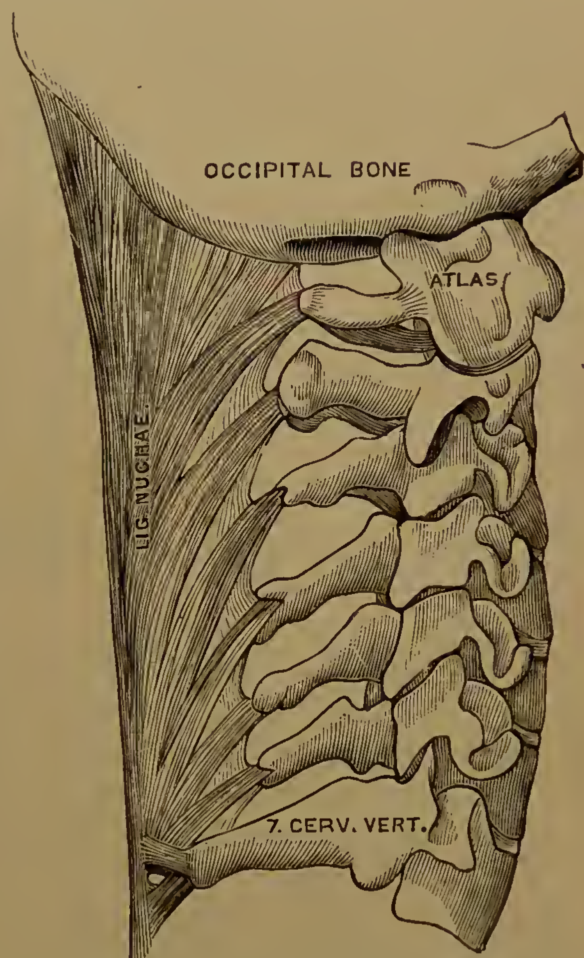

FIG. 247.—The ligamentum nuchæ, seen from the right side. (Henle.)

The *intertransverse ligaments* are unimportant and indistinct bands between ıe transverse processes. In the thoracic region they are rounded and small; ı the lumbar region they correspond to the ventral part of the superior costo- ·ansverse ligaments; and in the cervical region are wanting or replaced by the ›tertransversales muscles.

The *nerve-supply* is derived from the spinal nerves of the several regions.

Movements.—The spinal column must combine strength with mobility, for, as ıe axis of the skeleton, it has to bear great weight and resist shocks. For this eason, and to avoid injury to the contained spinal cord, it is necessary that the ıovement between any two vertebræ should be slight, while that of the column, s a whole, is very considerable. *Motion* occurs *in all directions* around the pulpy ortion of the discs as a centre, and is limited in part by the ligaments, in part y the articular processes, which thus steady the column. Motion is most free ·here the bodies are smallest or the intervertebral discs thickest. The former

condition is found in the cervical, the latter in the lumbar region, and these are the two most movable parts. The direction of motion in any region is regulated by the shape of the articular processes.

In the neck all movements are permitted by the obliquity of the articular processes. *Extension* is more free than elsewhere, and *flexion* is free, but less so than in the lumbar region. *Lateral flexion* is more extensive than in any other region, but it is a combination with *rotation*, neither motion occurring freely by itself, except in the lower cervical region, where rotation is free. But little motion is allowed between the axis and the third cervical vertebra, owing to the thinness of the disc and the overlapping of the axis in front.

In the thoracic region extension is checked by the overlapping of the laminæ and spines, as well as by the shape of the articular processes. The latter also prevent *flexion*. As the articular processes lie in the arc of a circle of which the centre is in front between the bodies, *rotation* is permitted and is most free in the upper part. *Lateral flexion*, otherwise possible, is prevented or greatly limited by the ribs.

In the lumbar region, owing to the thickness of the discs (especially between the lower three vertebræ), *flexion* is very free, *extension* moderately so. The centre of the circle in which the articular processes lie is situated posteriorly; but, owing to the fact that these processes do not fit closely together, a slight amount of *rotation* and some *lateral flexion* are permitted, the lateral motion being also limited by the great transverse diameter of the bodies.

Motion is therefore most free in regions whose curve is convex forward, whose spinal canal and the contained spinal cord are largest, and where there are no bony cavities containing viscera. The ligamenta subflava complete the spinal canal, prevent the capsular ligaments from being nipped between the articular surfaces during motion, and restore these surfaces to their normal position after movement. They have but little, if any, effect in limiting flexion or restoring the column to the erect position after flexion.

2. The Articulations and Ligaments between the Atlas, Axis, and Occipital Bone.

The essential difference between these and the intervertebral articulations in general lies in the absence or modification of the intervertebral discs. The specialization of motion between these three bones results in some differences in the ligaments, though most of them are the continuation of the series found below.

A. The Articulations between the Axis and the Atlas (Figs. 248, 249).—There are here two sets of *synovial joints* or articulations:

1. The joints between the superior articular processes of the axis and the lateral masses of the atlas are *arthrodial*. Each is surrounded by a *capsular ligament*, strengthened on the inner and dorsal aspect by an *accessory ligament*, which passes from the back of the body of the axis upward and outward, along the outer edge of the occipito-axial ligament, to the lateral mass of the atlas behind the transverse ligament.

2. The articulations of the odontoid process in the ring between the ventral arch of the atlas in front and the transverse ligament behind are of the *trochoides* class. There are two *synovial sacs*—one in front, between the odontoid process and the atlas; the other and more extensive one behind, between the odontoid process and the transverse ligament. These two sacs are separated by transverse fibres, which pass from the sides of the odontoid process to the atlas, in front of the tubercles for the transverse ligament. The *transverse ligament* is a thick, dense, and very strong band, which passes across the ring of the atlas between the tubercles on the inner side of its lateral masses. It is arched slightly backward, flattened from before backward, and cartilage-clad in front as it passes behind the narrowed and faceted neck of the odontoid, which it holds in place, and by so doing prevents the odontoid from pithing the spinal cord. Contrary to the common popular and professional belief this ligament seldom gives way in

ging. From and across the centre of its dorsal aspect thin bundles of fibres s upward and downward to the cranial aspect of the anterior border of the fora- ı magnum and to the dorsum of the body of the axis respectively. These ı the transverse portion form a cross, hence the name *crucial ligament*, some- es applied to the group. Two other ligaments unite the axis and atlas. The erior *atlanto-axial ligament* is a thin membrane between the ventral arch of the

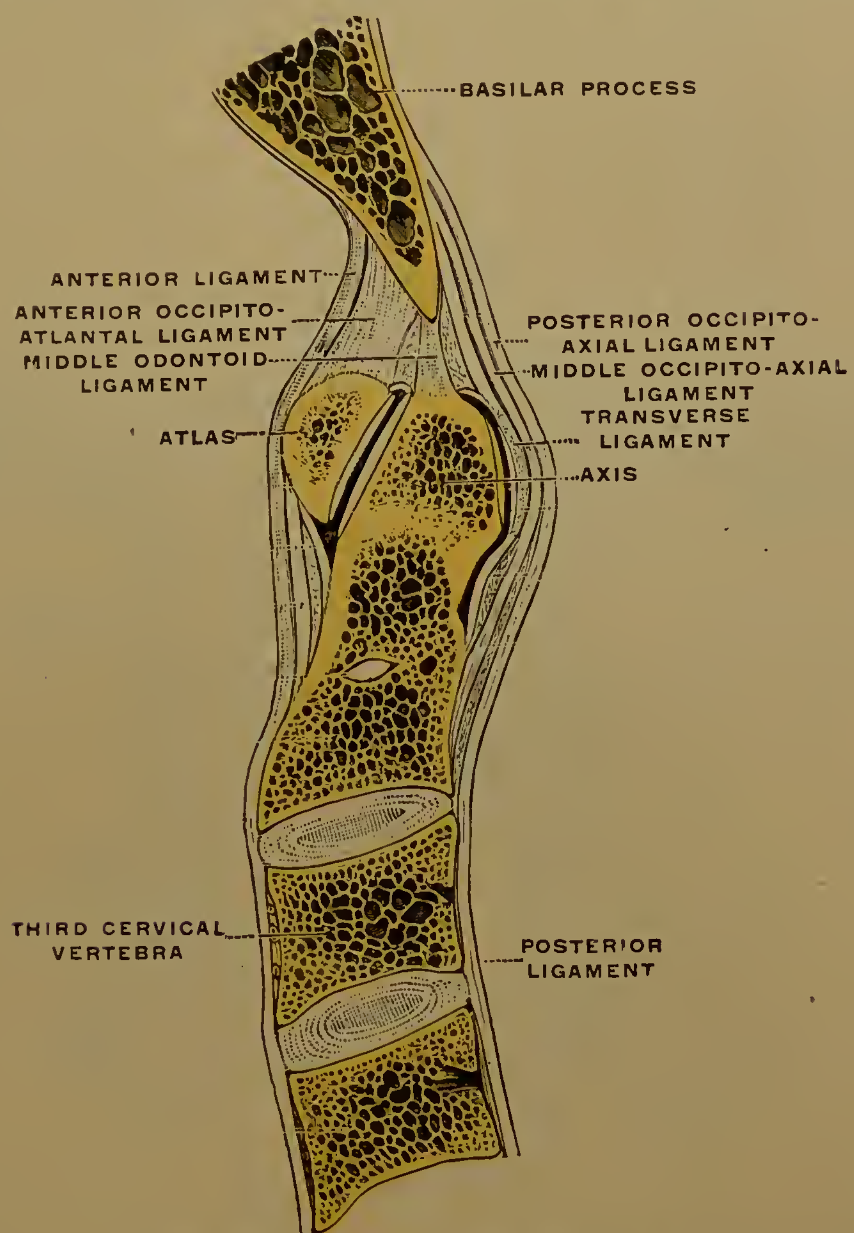

FIG. 248.—Sagittal section of the joints between the occipital bone and the atlas and axis. (Testut.)

ıs and the front of the body of the axis, representing the anterior common ıment, whose direct upward continuation is seen as a median cord-like thicken- of this ligament, which is attached to the ventral tubercle of the atlas. The sterior *atlanto-axial ligament* represents the ligamenta subflava, but has little stic tissue. It loosely connects the dorsal arch of the atlas and the laminæ of axis, and is perforated on each side by the second cervical nerves.

B. **Ligaments between the Axis and the Occipital Bone** (Figs. 248, 249).—e *occipito-axial* or *occipito-cervical ligament* is the upper end of the posterior nmon ligament extending from the third and second cervical vertebræ to basilar groove of the occipital bone. Some of its fibres pass over the axis thout attachment, giving rise to two layers, of which the hind one may be signated the *posterior*, and the forward one the *middle, occipito-axial ligament.* ıe *lateral odontoid*, *alar*, or *check ligaments* are two strong fibrous cords, which tend from the sides of the summit of the odontoid process transversely out- ırd to the rough impression on the inner side of each occipital condyle. They at a little higher level than the transverse ligament. Each is made tense by ·ning the head to the opposite side. The *middle odontoid* or *suspensory liga- nt* (anterior occipito-axial ligament) is a slender, median, fibrous band connect- g the apex of the odontoid and the fore part of the margin of the foramen ıgnum. It is relaxed by flexion, tightened by extension.

The suspensory ligament is derived from the sheath of the notochord, between the first vertebral centrum (the odontoid) and the basi-occipital, and is homologous with an intervertebral disc. The transverse and check ligaments are each derived from the *conjugal ligaments* (ligamentum conjugale costarum). These, in the embryo, connect the heads of each pair of ribs or costal processes around the back of the intervertebral discs, and persist as the interarticular ligaments of the heads of the ribs.

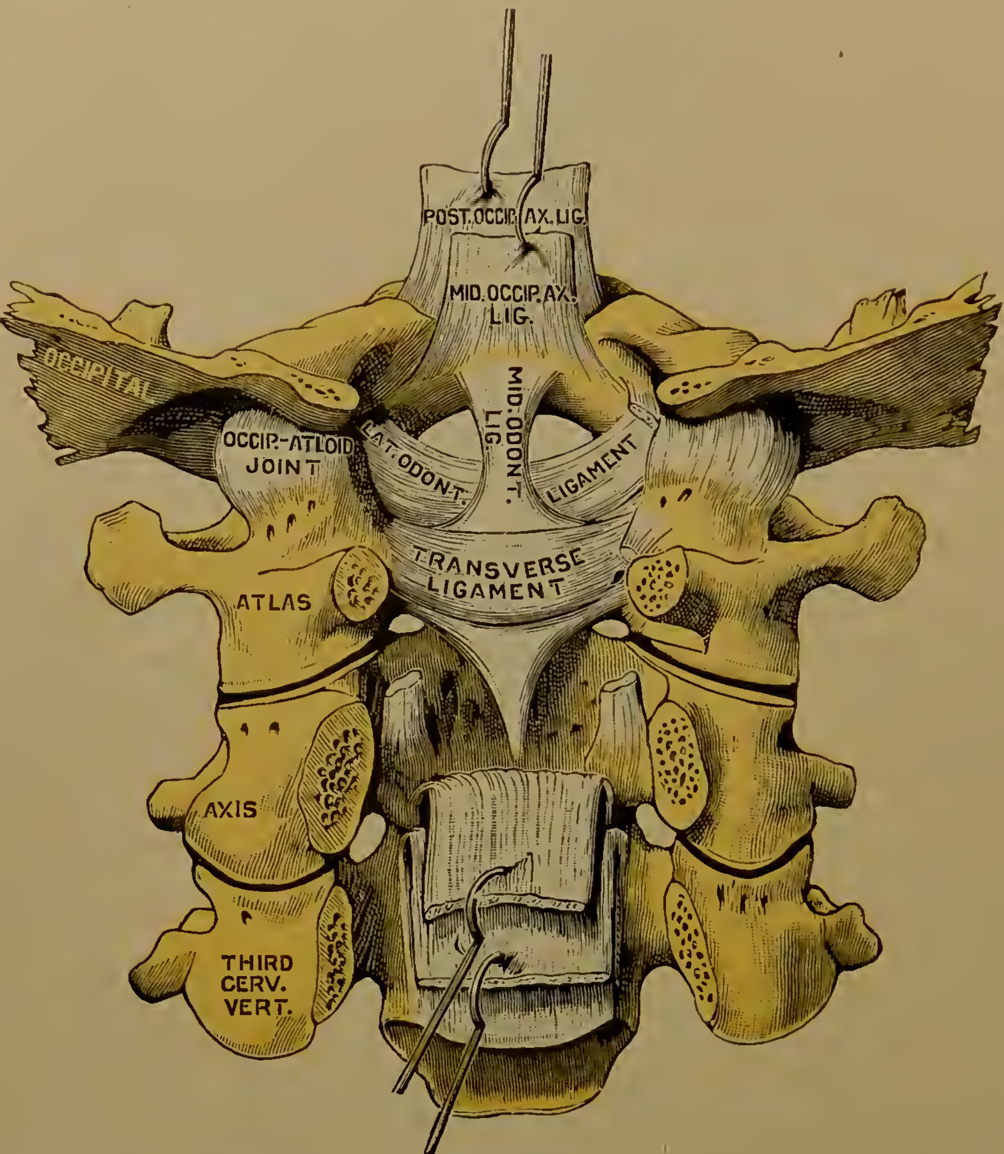

FIG. 249.—Articulations of the occipital bone with the upper cervical vertebræ. The arches have been removed, and the spinal canal is thus exposed. (Testut.)

Movements.—In the atlanto-axial articulation rotation of the head together with the atlas takes place around the odontoid process as a pivot for about 30° to either side in a nearly horizontal plane. It is limited by the check and atlanto-axoidean ligaments. As both facets in each lateral atlanto-axoidean articulation are convex, with the convexities in contact when the head looks forward, rotation causes the convexities of the atlantal facets to descend from those of the axis. This decreases the space and relaxes the ligaments between the bones, thus allowing further rotation, with security in all positions. Slight flexion and extension and some lateral flexion are also allowed between the atlas and the axis.

C. **The Articulation of the Atlas with the Occipital Bone.**—This consists of a symmetrical pair of condylar joints between the occipital condyles and the upper facets of the lateral masses of the atlas. Each joint is provided with a rather lax *capsular ligament.* In front and behind these the ventral and dorsal arches of the atlas are connected with the margins of the foramen magnum by the *anterior* and *posterior occipito-atlantal ligaments* respectively. The *anterior occipito-atlantal ligament* is thin and membranous, strengthened in front in the median line by a round *accessory ligament,* which is the upper end of the anterior common ligament. The *posterior occipito-atlantal ligament* represents the ligamentum subflavum, but is without elastic fibres, and is also thin and membranous.

iis ligament does not limit motion between the bones. The dura is adherent its ventral surface, and the dorsal surface lies in the floor of the suboccipital angle. A band of fibres at the lateral margins of the ligament arches over the ck of the vertebral groove on each side to the superior articular process, com- eting a foramen for the vertebral artery and the suboccipital nerve. The *lateral ipito-atlantal ligaments* are strong fibrous bands between the transverse processes the atlas and the jugular processes of the occipital on each side, which engthen the capsular ligaments externally, and lie behind the rectus capitis eralis muscles.

Movements of *flexion* and *extension* are freely allowed. Extension is checked the anterior occipito-atlantal, flexion by the occipito-axial and hind part of the psular ligaments. Some *lateral gliding* is also allowed, by which the outer ge of the condyle on the one side is depressed, and on the other is elevated in lation to its socket. Or the movement may be *obliquely lateral*, one condyle vancing slightly at the same time that it is depressed toward the median line, iile the opposite condyle takes the reverse position. This is the position of eatest stability, and is assumed in the most easy and natural attitudes. *Lateral ovements* are restrained by the check ligaments and the lateral parts of the cap- les. No true *rotation* is allowed.

The symmetrical and bilateral arrangement of these joints, combined with the edian odontoid pivot, provides equal freedom of motion and greater strength and curity than a ball-and-socket joint. A passageway for the cord is also provided, bject to less motion than in case the joint were of the ball-and-socket variety.

The ligaments passing over and between the odontoid process and the occiput being lax in the erect position allow of flexion, which tightens them. The ad balances upon the fore part of the condyles when the orbits look a little oward. By this arrangement, characteristic of the human figure, the head is ld erect without undue muscular effort or a strong ligamentum nuchæ. If the uscles relax, the head will nod either forward or backward according as the ntre of gravity is in front or behind the balance line.

3. **The Articulations of the Thorax** (Figs. 250, 251).

A. The **Costo-vertebral Articulations**, or those between the ribs and the ver- bræ, are subdivided into *costo-central* and *costo-transverse articulations*.

(*a*) In the *costo-central articulation* the head of the rib is united to the body a single vertebra in the case of the first, tenth, eleventh, and twelfth ribs, sewhere to the bodies of two vertebræ and the intervening intervertebral sc. When the rib-head articulates with a single vertebra, there is a single *novial sac*, otherwise two separate sacs, surrounded by a *capsular ligament*, hich is composed of short fibres and is reinforced in front by the *anterior sto-central* or *stellate ligament*. This consists of pearly-white fibres, radiating om the front of the head of the rib upward to the body of the vertebra above, rward to the intervertebral disc, and downward to the body of its proper ver- bra. In the case of the first, tenth, eleventh, and twelfth ribs the stellate rangement of fibres is not quite as distinct. The *interarticular ligament* is a iin, transverse band of short, strong fibres between the intervertebral disc and ie ridge separating the two facets on the head of the rib, excepting the first, nth, eleventh, and twelfth, where it is wanting. It separates the two synovial cs, and is loose enough to allow of moderate rotation.

Its *nerve-supply* is derived from the anterior branches of the thoracic nerves.

(*b*) The *costo-transverse articulation* is between the tubercle of each rib of the pper ten pairs and the front of the tip of the transverse process of the vertebra aring the same number as the rib. Each joint has a thin, loose *capsular liga- ent*, enclosing a *synovial sac*, and strengthened on three sides by the costo- ansverse ligaments. The *middle costo-transverse* or *interosseous ligament* consists short horizontal fibres between the back of the neck of the rib and the front

of the corresponding transverse process, extending from the capsule of the costo-central to that of the costo-transverse articulation. It is best seen in a transverse section, and is rudimentary in the case of the eleventh and twelfth ribs. The *posterior costo-transverse ligament* is a short strong band extending from the outer end of the transverse process outward and upward to the rough non-articular part of the tubercle of the corresponding rib. It is wanting to the eleventh and twelfth ribs. The *superior costo-transverse ligament* consists of a broad, flat, fibrous band between the upper border of the neck of each rib below the first, and the lower border of the transverse process next above it. Two layers are often distinguishable—the ventral, passing upward and outward, the dorsal and more scattered fibres passing upward and inward. Externally this ligament is continuous with the fascia lining the external intercostals; internally it presents a free margin and is thickened; in front it is in relation with the intercostal vessels and nerves.

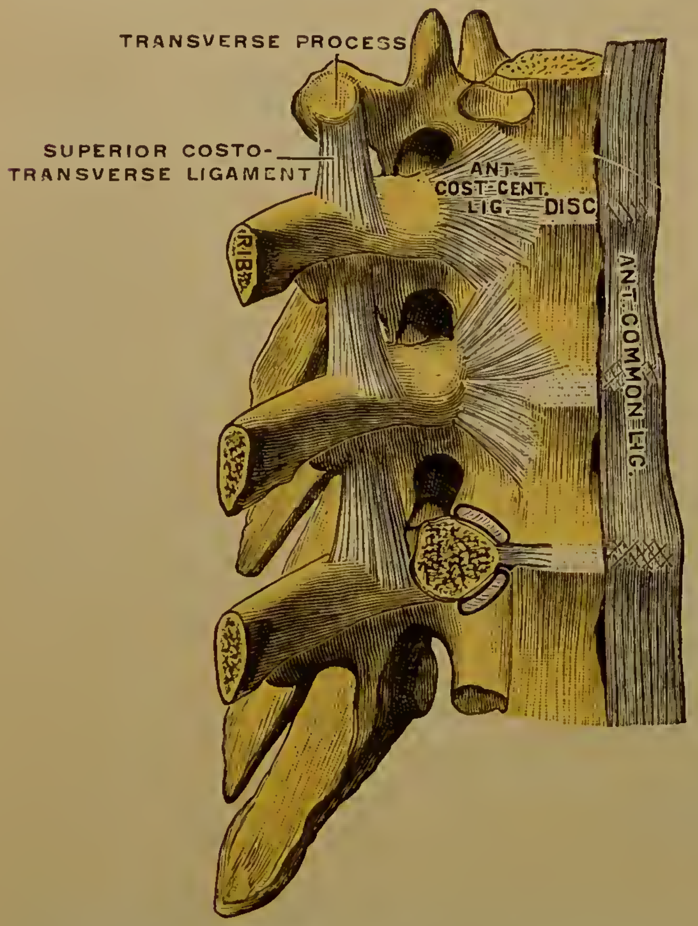

FIG. 250.—Articulation of the vertebral bodies with each other, and of the ribs with the spine. (Testut.)

FIG. 251.—Costo-vertebral articulations in horizontal section: upper surface of lower segment, right side. (Testut.)

B. The **Costo-chondral Synarthroses.**—The costal cartilages are joined to the cup-shaped ends of the ribs by the continuity of the investing perichondrium and periosteum.

C. The **Chondro-sternal Articulations** are between the facets on the lateral borders of the sternum and the inner ends of the cartilages of the upper seven (the sternal) ribs. The *first rib* is joined by *synarthrosis* to the sternum. The others have *synovial joints*, generally single, but in the case of the second rib usually double on one or both sides. When the synovial sac is double, an *inter-articular ligament* connects the ridge between the facets of the cartilage with the fibrocartilage between the manubrium and body of the sternum. A similar ligament sometimes exists in the other joints. The synovial sac is frequently obliterated in the joints of the sixth and seventh cartilages. The chondro-sternal joints are surrounded by short *capsular ligaments*, most developed in front, above, and below, where they are called, respectively, *anterior*, *superior*, and *inferior chondro-sternal ligaments*. In the *anterior ligament* the fibres radiate from the front of the inner end of the cartilage to the front of the sternum, where they decussate with the opposite ligament and adjoin those above and below. The so-called *posterior chondro-sternal ligament* is little more than the continuity of periosteum and perichondrium

h a few accessory capsular fibres. The *chondro-xiphoid ligament* is a flat band nnecting the front of the xiphoid cartilage with that of the seventh, and often the sixth, costal cartilage.

D. The **Interchondral Articulations** are arthrodial joints between the cartilages m the sixth to the ninth (inclusive), situated a little in front of their upward id, where blunt processes on the lower edges come in contact with the upper rgins of the cartilages below. They have a complete *capsule* enclosing a *ovial sac,* and reinforced by oblique fibres from the anterior intercostal fascia.

E. **Sternal Articulations.**—The union of the manubrium and body of the rnum forms a symphysis in which the connecting fibro-cartilage may contain artial synovial cavity with a layer of cartilage above and below. The fibres the radiating chondro-sternal ligaments and the periosteum, reinforced by gitudinal fibres in front and behind, but especially behind, strengthen the ion of these two parts. The xiphoid cartilage is similarly united synar-odially to the lower end of the body of the sternum, at a level somewhat behind t of the ventral surface of the sternum. The chondro-xiphoid ligament is an essory ligament of this joint. Both of the connecting cartilages, but especially sterno-xiphoid, may ossify in old age.

Movements of the Ribs and of the Thorax as a Whole (Fig. 252).—In inspira-n the thorax is enlarged in its three diameters, transverse, antero-posterior, and rtical. The increase in the vertical meter is caused partly by the eleva-n of the upper ribs, and the result-; widening of the intercostal spaces, : is mainly due to the action of the phragm. The increase in the other ɔ directions is due to the move-nts of the ribs, which are greatest ere the ribs are longest, most ob-ue, and most curved at their angles *e.,* at the sixth, seventh, and eighth s opposite the bulkiest part of the igs), and least in the short, flat first d second ribs.

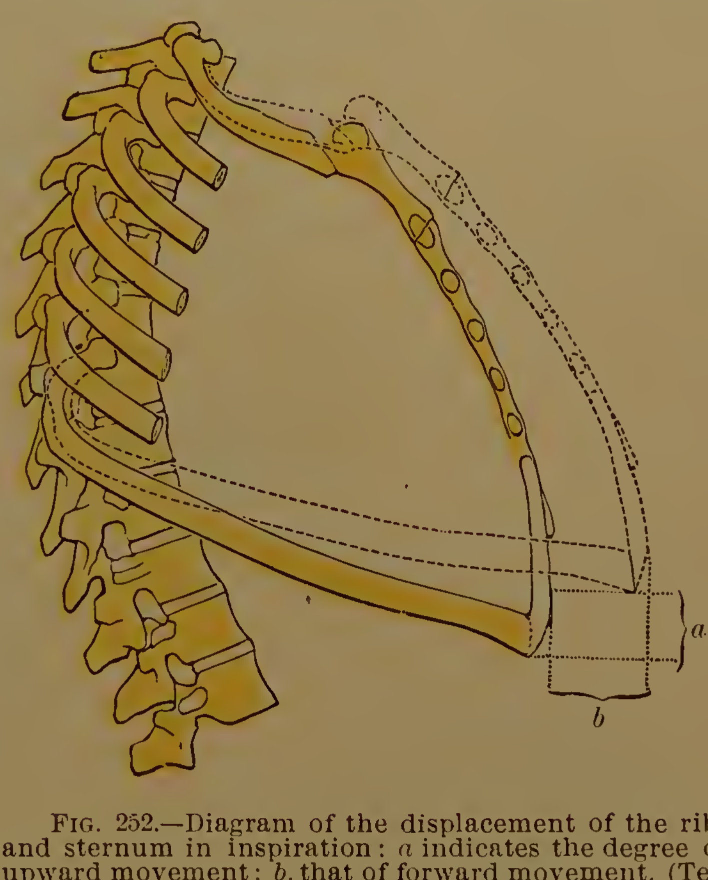

Fig. 252.—Diagram of the displacement of the ribs and sternum in inspiration: *a* indicates the degree of upward movement; *b*, that of forward movement. (Testut.)

As the ribs articulate with the rtebræ by two series of closely ap-oximated joints, the axis of *rotation,* ich is the chief movement here, ist pass through both joints—*i. e.,* liquely outward, backward, and newhat downward. When the *up-rd rotation of inspiration* occurs, the ntral ends of the ribs, which are lined obliquely downward, are elevated. By thus decreasing the obliquity of ribs the front wall of the thorax is carried upward and forward, and its cavity enlarged sagittally. The ventral ends of the ribs cannot be elevated without aightening out the angles with the costal cartilages, which throws this end of the s outward, increasing the transverse diameter anteriorly. The return of the cos-cartilages to the natural angle after inspiration is a principal factor in the iliency of the thorax, to which quiet expiration is largely due. As the *axis of ation* is *oblique,* upward rotation also elevates the lateral part of the ribs and rts their lower borders, thus increasing the transverse diameter behind. In the t ribs the axis is more nearly transverse; hence their motion is mostly a slight vation and depression of their fore parts. But as the obliquity of the axis in-ases from above downward, the outward movement becomes more extensive in lower ribs. Owing to the plane and sloping articular surfaces on the trans-rse processes of the vertebræ, from the seventh to the tenth only, there is, besides

rotation, a slight backward and upward motion at the costo-transverse joint in inspiration and the opposite in expiration, which is still more marked in the eleventh and twelfth ribs, where there are no costo-transverse articulations. In the upper six ribs, where the facets on the transverse processes are situated lower and are more concave as we ascend, there is rotation only. In the case of the eleventh and twelfth ribs there is little elevation, and the twelfth rib may even be drawn downward in inspiration by the quadratus lumborum. The widening of the lower part of the thorax in inspiration increases the power of the diaphragm and counteracts the compression of the abdominal viscera. The costo-vertebral articulations with their ceaseless movement are remarkable for their freedom from disease.

At the chondro-sternal articulations, except the first, there is a slight hinge-motion on two axes, sagittal and obliquely vertical. Owing to these two movements the sternum is carried neither so far forward nor upward as the anterior ends of the ribs and cartilages. Unless thus limited, its motion would be detrimental to the heart and great vessels behind it. In the interchondral joints only a limited gliding is allowed, and the sternal articulations merely increase the elasticity and strength of the sternum.

The hinge-motion, often wrongly ascribed to the ribs at the costo-central joints, can only occur with a sliding motion at the costo-transverse articulation. Although this may occur in the lower ribs, it cannot in the upper, owing to the rounded concavities in the transverse processes. Slight rotation on a single axis, as above indicated, accounts for all the motions ascribed to the ribs.

4. **The Temporo-mandibular Articulation** (Figs. 253–255).

This articulation consists of a pair of symmetrically placed *ginglymo-arthrodial* joints. Their dissimilar articular surfaces, the ventral halves of the glenoid fossæ, and the articular eminences of the squamous portions of the temporal bones

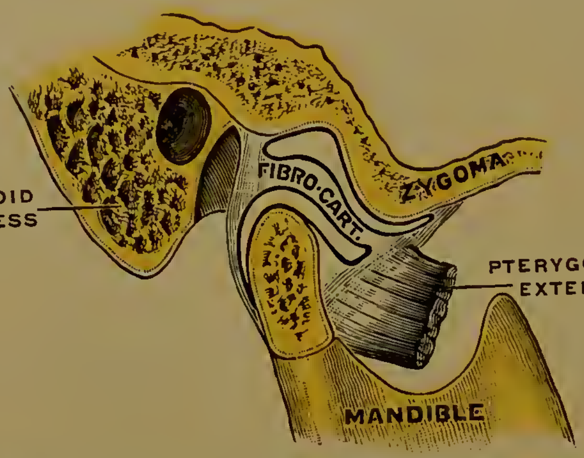

FIG. 253.—Temporo-mandibular articulation in sagittal section. (Testut.)

above and the condyles of the mandible below, are adjusted to one another by the interposed interarticular cartilages. The joint is best seen when the jaw is divided in front of the ramus, and the latter is freed from its attachments.

The bones are united by a thin loose *capsular ligament* attached outside of the articular surfaces on the two bones. The *external lateral ligament* consists of those accessory fibres, strengthening the capsule, which pass from the lower border and tubercle of the zygoma downward and backward to the outer side and back of the neck of the condyle. This ligament on either side serves as the internal lateral ligament of the opposite side. The inner part of the capsule, sometimes called the short internal lateral ligament, does not deserve the name.

The *interarticular cartilage* is a thin, oval plate of fibro-cartilage, concavo-convex from before backward on its upper aspect to fit the temporal surface, and concave below to receive the condyle of the lower jaw. It is thickest behind, and thinnest at the centre, where it is sometimes perforated. By the close attachment of its circumference to the capsule the joint is divided into *two synovial cavities*, of which the upper is the larger and looser, and the lower extends lower

own behind than in front. The two sacs communicate when the cartilage is perforated. Some fibres of the external pterygoid muscle are inserted into the cartilage in front.

The *accessory ligaments* are—(1) the *spheno-mandibular* or *long internal lateral ligament*, a thin band some little distance from the joint, extending from the

FIG. 254.—Temporo-mandibular articulation, external view. (Testut.)

spine of the sphenoid downward and a little forward to the lingula of the mandible. Separating it from the joint and the ramus are the external pterygoid muscle, the internal maxillary vessels, the inferior dental nerve and vessels, the auriculo-temporal nerve, and the middle meningeal artery. It represents the fibrous remains of a part of Meckel's cartilage. (2) The *stylo-mandibular ligament* is a specialized band of the deep cervical fascia extending from near the tip of the styloid process to the angle and the posterior border of the ramus of the jaw, between the masseter and internal pterygoid muscles. It separates the submaxillary from the parotid gland.

The *nerves* supplying the joint are branches of the masseteric and auriculo-temporal.

The *movements* in this joint are—(1) the *hinge-motions* of *elevation* and *depression*, and (2) the *gliding motions* of *protrusion* and *retraction*, both (*a*) simple and (*b*) oblique or grinding. The movements in the two synovial compartments are of different kinds. In the upper there are a protrusion and a retraction, or a forward and a backward gliding, of the cartilage together with the condyle on the temporal bone, due to the closer connection of the cartilage with the condyle than with the temporal bone, and to the insertion of the external pterygoid or protrusor muscle into both cartilage and condyle. In the lower part there is a hinge-motion, on a transverse axis, between the condyle and the cartilage.

FIG. 255.—Temporo-mandibular articulation, mesial view. (Testut.)

In opening the mouth the (1) hinge and (2*a*) simple gliding motions are combined. When the mouth is opened but slightly (as in talking) there is simply a hinge-motion in the lower compartment. When, however, the mouth is opened more and more widely, besides an increased hinge-motion, the cartilage and condyle glide forward onto the articular eminence. The condyle does not normally reach the summit of the eminence, but when, as in a convulsive yawn, it glides over the summit, it slips into the zygomatic fossa, and there is a dislocation with rupture of the back of the capsule. As the cartilage and condyle glide forward the external lateral ligament remains always tense on account (1) of the downward movement onto the eminence, (2) of the increased hinge-motion (depression) which the ligament allows when its obliquity is straightened by the forward movement of the condyle. The point of least motion, or the axis of motion, in the combined movement is approximately at the inferior dental foramen, and thus stretching of the nerve is avoided. The combination of hinge and gliding motion gives a tearing as well as a cutting action to the incisors.

(2*a*) There may be a *simple protrusion and retraction* of the lower jaw by a gliding motion in the upper compartment. A slight lowering of the rami occurs as the cartilages and condyles pass downward and forward onto the eminences. (2*b*) An *obliquely horizontal* or *rotary grinding* motion is caused by the alternate gliding forward on one side, and backward on the other.

THE ARTICULATIONS OF THE UPPER EXTREMITY.

1. The Sterno-clavicular Articulation (Fig. 256).

The arthrodial joint between the inner end of the clavicle and the superior angle of the manubrium sterni, together with the cartilage of the first rib, is the only point of attachment of the skeleton of the shoulder-girdle and upper limb to that of the trunk. The dissimilar articular surfaces are adjusted to one another by the intervening *fibro-cartilage*, and are connected together by a fairly tight *capsular ligament*, whose fibres pass obliquely upward and outward from the circumference of the sternal to that of the clavicular facet. This capsule is strongest behind and in front, where it is called respectively the *posterior* and the *anterior sterno-clavicular ligaments.* Above it is supplemented and strengthened by the dense *inter-*

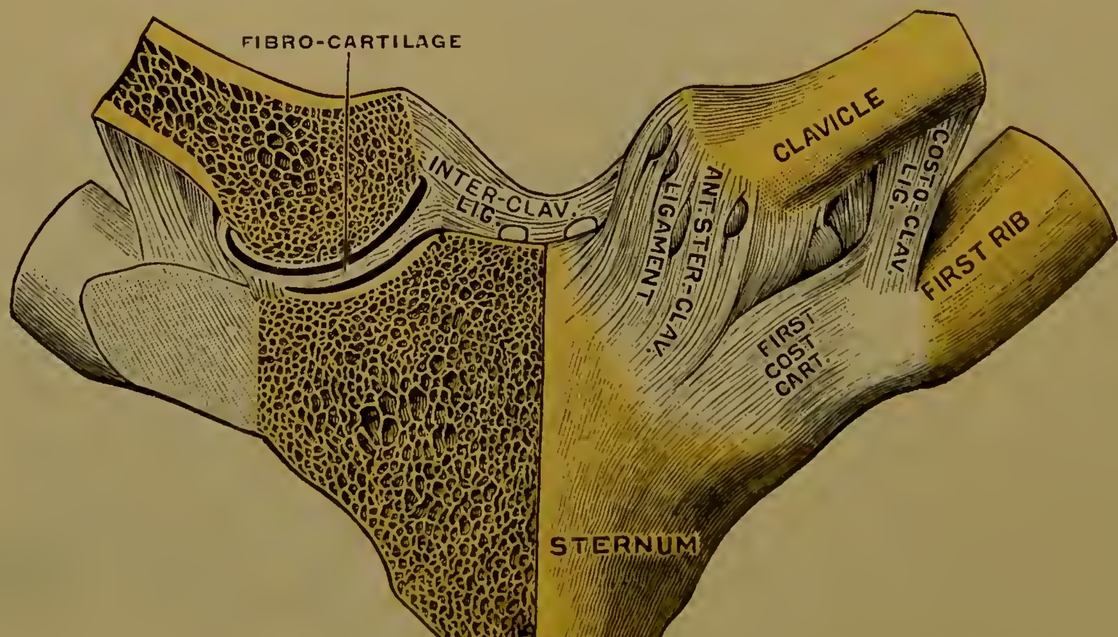

FIG. 256.—Sterno-costo-clavicular articulation, front view. The right half is seen in coronal section. (Testut.)

clavicular ligament which passes between the upper and back parts of the sternal ends of the two clavicles and their capsular ligaments, and dips down in the middle to be attached to the posterior border of the interclavicular notch of the sternum. Below, where the capsule is thinnest, is the strong, dense, accessory band,

· *costo-clavicular* or *rhomboid ligament*. This is directed obliquely upward, out-rd, and backward from the front and upper aspect of the first costal cartilage the rhomboid impression on the under surface of the inner end of the clavicle.

The *interarticular fibro-cartilage* is a flattened disc of about the same shape d size as the inner articular surface of the clavicle. It is thinnest at the centre d below, thickest above. It is attached above to the upper and dorsal border the articular surface of the clavicle and below to the inner end of the cartilage the first rib. By the attachment of its circumference to the inner surface of · capsule the joint is divided into two *synovial cavities*, of which the outer is ; looser, and is continued a short distance beneath the clavicle on the first costal rtilage. The two occasionally communicate through a perforation in the centre the fibro-cartilage.

The fibro-cartilages and interclavicular ligament together represent the epi-rnal bone of lizards.

The *nerve-supply* comes from the nerve to the subclavius muscle.

Movements.—The clavicle carrying the scapula, to which the coraco-clavicular aments closely bind it, may move on its inner end as a centre in an upward d downward direction on a sagittal axis; in a forward and backward direction a vertical axis; or, by a combination of these, a circumductory motion may obtained, in which the clavicle describes a cone of which the base is at its outer d. A slight rotation of the clavicle on its long axis is also permitted by which ventral surface is turned upward as the arm is raised, and *vice versâ*.

The fibro-cartilage serves as an elastic buffer to break shocks and resist pressure m the shoulder, as well as to connect the bones and prevent inward displace-nt. The interclavicular and rhomboid ligaments are safeguards against ward displacement of the inner end of the clavicle in depression and elevation the arm, and the rhomboid ligament also resists backward displacement. hen one clavicle is much depressed the interclavicular ligament draws the her one up—a fact to be remembered in fracture of the bone. In forced pression of the clavicle it presses on the first rib, which acts as a fulcrum, so at the inner end is raised and its ligaments are put on the stretch.

2. The Scapulo-clavicular Articulation.

The **Acromio-clavicular Joint** is an arthrodial articulation between the bevelled iter end of the clavicle and the inner margin of the acromion process, in hich the bones are held together by a somewhat lax capsule, which allows me play between the surfaces. The capsule, whose fibres pass from the acro-ion inward and backward, is especially strong above, forming the *superior romio-clavicular ligament*, and is here also strengthened by the fascia of the apezius and deltoid. The inferior part, *inferior ligament*, is weak, as is also the osterior. The *synovial cavity* is sometimes partially, rarely completely, divided to two by a small wedge-shaped *interarticular fibro-cartilage*, attached by its base the superior ligament, and usually occupying the upper part of the joint only.

The **Coraco-clavicular Ligament**, which binds the clavicle to the coracoid process f the scapula, is the strongest connection between the clavicle and scapula, and nsists of two parts: (1) The *conoid ligament*, the dorsal and internal fasciculus, a strong triangular band attached by its apex to the inner and back part of the ot of the coracoid process, from which its fibres spread upward, backward, nd outward to and about the conoid tubercle of the clavicle. (2) The *trapezoid gament* is the flat, quadrilateral, outer and fore part, whose fibres slope upward, ackward, and outward from the upper surface of the dorsal half of the coracoid rocess to the trapezoid ridge on the under surface of the clavicle. A small ursa often exists between these two ligaments.

Filaments from the circumflex and suprascapular *nerves* supply the joint.

Movements in the acromio-clavicular joint may take place on a *vertical axis* by hich the glenoid cavity is turned farther backward or forward, thus enabling it

to keep its relative position in forward or backward movement, respectively, of the shoulder-girdle. Or movement may take place on a *horizontal axis*, by which the glenoid cavity is turned farther upward or downward, as when the arm is raised or lowered. This motion, combined with elevation and depression of the clavicle, is spoken of as *rotation of the scapula* on a dorso-ventral axis passing through its centre or its upper angle. The movements at the acromio-clavicular joint, modifying the relation of the scapula to the clavicle, rarely take place by themselves, but only in connection with the movements of the sterno-clavicular joint. In the combined movements of the clavicle and scapula the movements of the scapula are restricted by the shape of the chest-wall on which it lies, so that its principal movements are upward and forward, and downward and backward. In the above movements the vertebral border and the lower angle of the scapula are generally kept in contact with the thorax by the muscles attached—a condition allowed only by the acromio-clavicular joint. The conoid ligament suspends the scapula from the clavicle; the trapezoid is tightened when the shoulder is pressed inward.

The **Ligaments of the Scapula** (Fig. 257).—The *coraco-acromial ligament* is a flat, triangular band attached by its broad base to the outer border of the coracoid process and by its blunt apex to the tip of the acromion. Binding together the acromion and coracoid processes, it forms an arch over the shoulder-joint which holds off the deltoid, and supports and protects the joint. Its ventral and dorsal margins are thick and strong, leaving a thin membranous part between, with often a gap near the coracoid process. The deltoid covers its upper surface, which also looks a little forward; its lower surface is separated by a bursa from the capsule of the shoulder-joint. From its outer edge, which projects over the centre of the head of the humerus, a thin, tough fascia is continued under the deltoid and over the subacromial bursa and the shoulder-joint. The *transverse, coraco-scapular* or *suprascapular ligament*, continuing the upper border of the scapula, bridges across the suprascapular notch, converting it into a foramen, through which the suprascapular nerve passes, while the corresponding artery commonly passes above it. It is thin and flat, and is sometimes replaced by bone. The *spino-glenoid ligament* comprises a few lax fibres which, by passing between the outer border of the spine and the margin of the glenoid cavity, bridge over the suprascapular vessels and nerves in passing between the supra- and infraspinous fossæ.

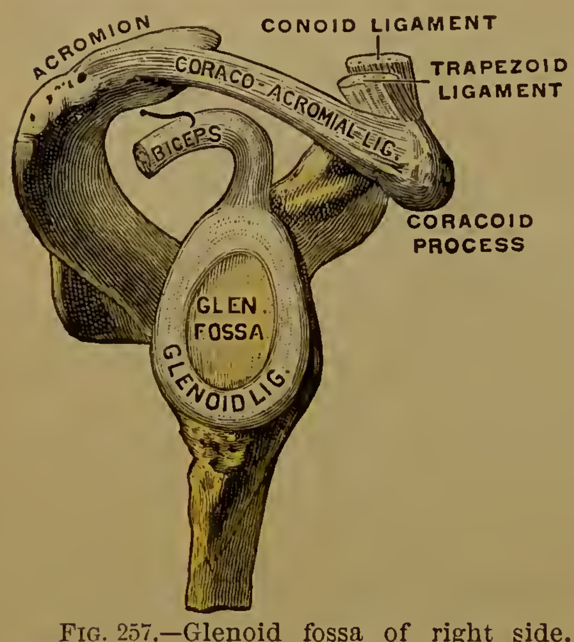

FIG. 257.—Glenoid fossa of right side. (Testut.)

3. The Shoulder-joint (Figs. 258–260).

This ball-and-socket joint, between the large humeral head and the small, shallow glenoid cavity of the scapula, is one of the most perfect and most movable of joints. The surrounding muscles give strength and security to the joint, and, together with atmospheric pressure, hold the bones in position much more than do the ligaments. The glenoid fossa is deepened by the *glenoid ligament*, triangular on section with the base attached around the margin of the fossa. It is composed of fibro-cartilage with scattered cartilage-cells. To its upper end is attached the long tendon of the biceps, which, dividing, is continued into both sides. Outside of this ligament the *capsular ligament* is attached to the scapula around the glenoid margin, sometimes reaching as far as half an inch from it in front. From this attachment it passes to the anatomical neck of the humerus. At the lower and inner part of the latter it is attached some distance from the

icular surface, and in front, between the tuberosities, it covers over and is ached to the transverse ligament, thus giving passage to the long tendon of the eps. The capsule is composed of longitudinal fibres, with some oblique and cular fibres interwoven, and is strongest on its superior aspect. It is so lax

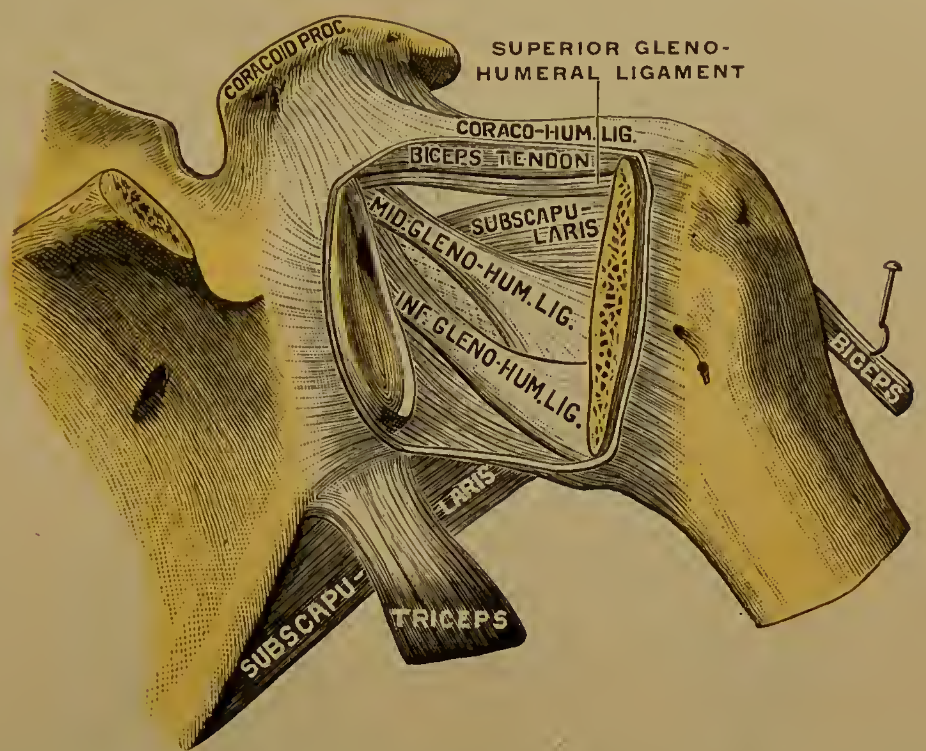

FIG. 258.—Shoulder-joint, rear view. The hind part of the capsular ligament and most of the head of the merus have been removed. (Testut.)

at alone it does not keep the bones in contact. Above and behind the tendons the supraspinatus, infraspinatus, and teres minor, in front that of the subapularis and below the long head of the triceps are intimately connected with d strengthen the capsule. Between the subscapularis and triceps tendons is an

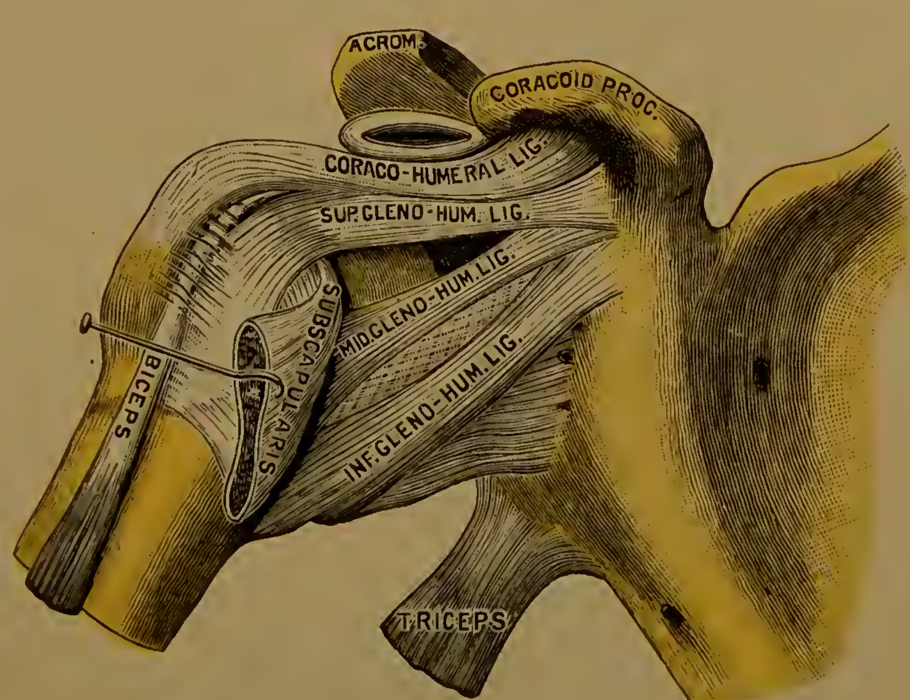

FIG. 259.—Shoulder-joint, front view. (Testut.)

nprotected and weak part of the capsule. This is the part usually torn by the ssage of the head in dislocations, to which the shoulder is very liable, owing in rt to the looseness of its capsule. Besides the overlying tendons the capsule s two sets of accessory folds.

(1) The *coraco-humeral ligament* extends as a strong, broad band from the ter border and root of the coracoid process, beneath the coraco-acromial ligaent, obliquely over the joint to the anatomical neck of the humerus above the reat tuberosity, being intimately connected with the capsule. Seen from in front, appears as a fan-shaped process lying over and above the capsule, with which it

appears continuous as viewed from behind. This ligament represents a detached part of the pectoralis minor tendon. (2) The *gleno-humeral bands,* three in number, extend between the ventral margin of the glenoid fossa and the neck of the humerus. They are seen projecting on the interior of the inner and fore part of the capsule when the joint is opened from behind. The *superior gleno-humeral band* extends between the upper end of the ventral margin of the glenoid cavity and the upper end of the small tuberosity of the humerus, forming a slight groove, directed backward, for the inner edge of the biceps tendon. It may occasionally be quite free from the capsule, and it lies above the opening by which the bursa beneath the subscapularis tendon communicates with the synovial

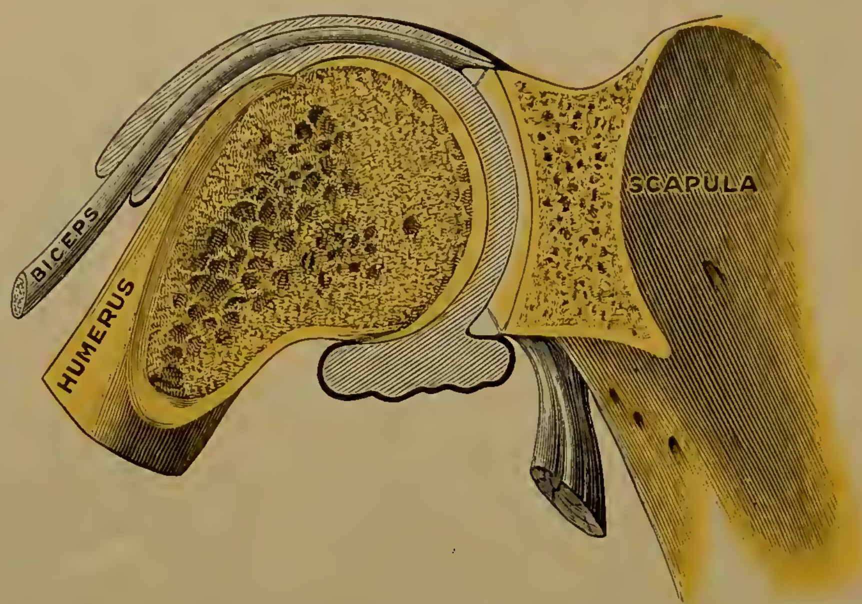

FIG. 260.—Shoulder-joint in coronal section, front view. The synovial sac is distended. (Testut.)

cavity of the joint. The *middle gleno-humeral band* lies below this opening, along the lower border of the subscapularis. It arises from the glenoid margin with the superior band, and is attached to the inner side of the small tuberosity of the humerus. The *inferior gleno-humeral band* is the strongest, and passes between the middle part of the ventral border of the glenoid rim and the lower part of the neck of the humerus. The superior gleno-humeral band represents the divorced tendon of the subclavius muscle as seen in birds, and corresponds to the ligamentum teres in the hip.

The *transverse ligament,* by means of its fibres passing transversely between the tuberosities, forms a canal of that part of the bicipital groove which belongs to the epiphysis. The capsular ligament is attached to it superficially.

The *synovial membrane* lines both free surfaces of the glenoid ligament, and is reflected thence over the inner surface of the capsule to the humeral neck, where in front it passes down the bicipital canal for a distance, and there is reflected onto the biceps tendon, which it sheathes, as it passes through the joint, as far its attachment to the glenoid ligament. Between the superior and middle gleno-humeral bands there is usually an opening where the synovial membrane is continuous with that lining the bursa beneath the subscapularis tendon. It occasionally communicates with a bursa beneath the infraspinatus muscle.

The articular cartilage is thicker near the centre of the head on the humerus and at the margins of the glenoid fossa, thus deepening it.

Nerves from the suprascapular, circumflex, and subscapular supply the joint.

Movements.—Flexion and extension, abduction and adduction, circumduction and rotation are allowed to a degree determined by the extent of the humeral articular surface, the length of the capsule, and the resistance of the overlying parts. Flexion and extension, or the movements forward and slightly inward, and backward and slightly outward, take place on an axis corresponding to that of the head and neck of the humerus, which is nearly perpendicular to the centre of the glenoid cavity. Flexion is much more free than extension, and between

e extremes of both there is about 90° of motion. In abduction and adduction e arm moves away from or toward the body, respectively, on a horizontal axis right angles with that last named, and parallel to the surface of the glenoid ssa. In extreme abduction (*i. e.*, to about 90°) or extension the great tuberosity rikes against the coraco-acromial ligament and the acromion process, and further otion is thus limited. The great freedom of motion at the shoulder, by which e arm can be raised so as to be nearly vertical, is in part due to the movement the scapula, which always accompanies movements at the shoulder-joint. Both oduction and flexion over 90° are due to rotation of the scapula, by which the enoid cavity is turned outward and upward, or forward and upward. Rotation ccurs in an outward (or backward) and in an inward (or forward) direction on an xis drawn from the centre of the head to the inner condyle of the humerus, and ver a range of between 90° and 100°. In extreme abduction the lower part of ie capsule is tense. In outward rotation the coraco-humeral ligament is made ense, and in both inward and outward rotation the upper part of the capsule is ghtened by twisting. Otherwise, the muscles rather than the ligaments restrain ie movements. In dislocation the coraco-humeral ligament is thought to be nportant in determining the position of the dislocated limb and the manipula- ion for its reduction.

The *subacromial bursa* lies between the joint-capsule, with its attached ten- ons, and the arch formed by the coracoid and acromion processes and the coraco- cromial ligament, and it also extends beneath the deltoid muscle. It facilitates he movements of the upper end of the humerus. The coraco-acromial arch orms a sort of secondary socket, against which the head and tuberosities of the iumerus are pressed when the weight of the body is supported by the arms.

The *biceps* tendon acts as a ligament of the joint, preventing the humerus rom being pulled up forcibly against the acromion, and keeping the head in the glenoid socket, especially when the arm is away from the side of the body and s pulled down by the pectoralis major and latissimus dorsi muscles.

4. **The Elbow-joint** (Figs. 261–263).

This is a true hinge-joint between the trochlear surface of the humerus and the great sigmoid cavity of the ulna. It is broadened, and thereby secured against

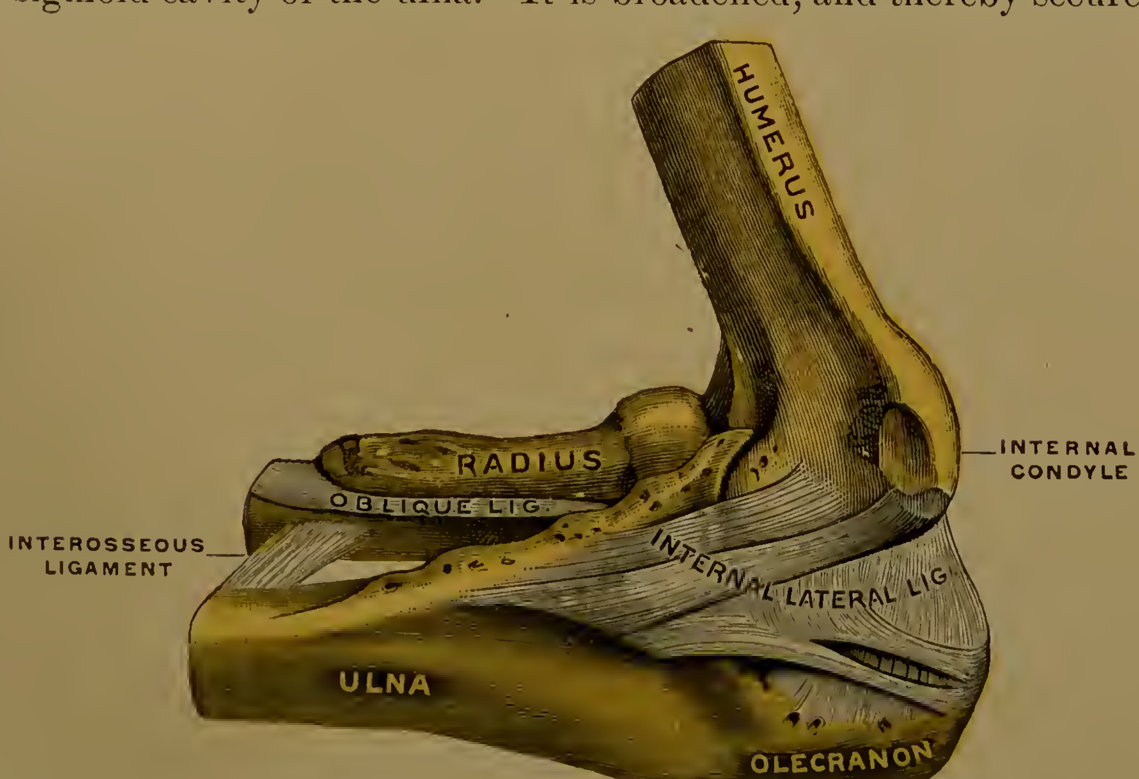

FIG. 261.—Elbow-joint, mesial view. (Poirier.)

lateral motion or displacement, by the articulation of the upper end of the radius with the capitellum of the humerus. To the shape of the bones is due the strength and security of the joint. Beneath the surrounding muscles and ten-

dons, which further strengthen the joint, lies the fibrous *capsule*, reinforced internally and externally, and therefore described in four parts.

The triangular *internal lateral ligament* is attached by its apex to the lower aspect of the internal condyle, and by its base to the inner margin of the coronoid and olecranon processes. It is divided into two smaller triangles, ventral and dorsal, by an intermediate thinner part attached to the meeting-point of these two processes. This ligament is the strongest part of the capsule.

The *external lateral ligament*, shorter and narrower than the internal, radiates from its upper attachment on the lower part of the external condyle to the outer side of the orbicular ligament. A few fibres reach the neck of the radius.

The *anterior ligament* is the thin, fore part of the capsule between the lateral ligaments. Superiorly it is attached above the coronoid and radial depressions, and includes them within the joint; inferiorly it is attached, just beyond the articular margin, to the front of the coronoid process and to the orbicular ligament, some fibres passing to the neck of the radius. It is reinforced by the adhesion of some of the fibres of the brachialis, which draws it up in flexion and prevents it from being nipped between the bony margins.

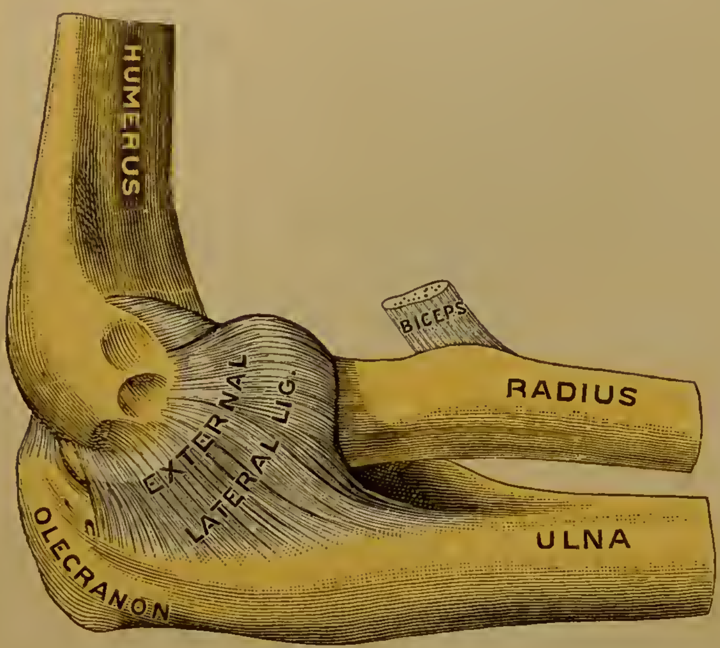

FIG. 262.—Elbow-joint, outer side. (Testut.)

The *posterior ligament* is thin and weak, like the anterior. By its attachment above and at the sides of the olecranon fossa it includes the latter within the joint. Its upper fibres pass transversely across the fossa. Inferiorly it is attached to the olecranon process, near the upper and outer margins of the great sigmoid cavity, to the orbicular ligament, and to the ulna behind the small sigmoid cavity. It is strengthened by the adhesion of the triceps, which draws it up during extension.

The *synovial membrane* lines the inner surface of the capsule, and thence passes onto the humerus, where it lines the olecranon, coronoid, and radial fossæ, and extends to the articular cartilage. Projecting into the above fossæ are masses of fat placed between the capsule and the synovial membrane. Inferiorly the membrane extends into the superior radio-ulnar joint, where it lines the orbicular ligament, thence passing onto and around the neck of the radius, and so up to its articular cartilage. A fold of synovial membrane, projecting into the joint from in front opposite the outer lip of the trochlea, suggests the division of the joint into two parts.

The *nerve-supply* is mainly from the musculo-cutaneous, with a few filaments from the musculo-spiral, median, and ulna.

Movements are confined to flexion and extension on an axis obliquely placed at an angle of about 84° with the shaft of the humerus, so that in extension the forearm is inclined outward and in flexion inward. Flexion occurs through 140°, and is limited by the contact of the soft parts; extension is limited, when the ulna and humerus are nearly in line, by the tension of the soft parts and ligaments in front, and of the ventral portions of the lateral ligaments. The olecranon and coronoid processes do not arrest normal but only forced motion, by contact with the bottoms of their respective fossæ. The head of the radius moves on the capitellum, and is in most complete contact with it in semiflexion, in which position it rotates best on the humerus in pronation and supination. Except possibly to a very limited extent, owing to the slight incongruence of the surfaces, lateral motion is prevented by the lateral ligaments and the shape of the bones.

When the elbow is extended the tip of the olecranon lies on or just below a ıe connecting the two condyles: when flexed to a right angle it lies a little more an one inch below, and midway between these two points.

5. Radio-ulnar Articulations.

Two joints and an intermediate fibrous union connect the ulna and radius rmly together.

(A) The **Superior Radio-ulnar Articulation.**—The rim of the head of the radius held in contact with the small sigmoid cavity f the ulna by the strong encircling *orbicular ligment.* This forms four-fifths of a circle and is ttached to the ventral and dorsal lips of the mall sigmoid cavity, which completes the ring. t forms part of the capsule of the elbow-joint, nd inserted into it are the external and parts f the ventral and dorsal portions of this capsule. ts lower border tightly girdles the neck of the adius. From this border membranous fibres ass to the neck of the radius loosely enough o allow of rotation of the radius on its long axis. t is lined by *synovial membrane* continuous with hat of the elbow-joint, and its *nerve-supply* is erived from that of the elbow-joint.

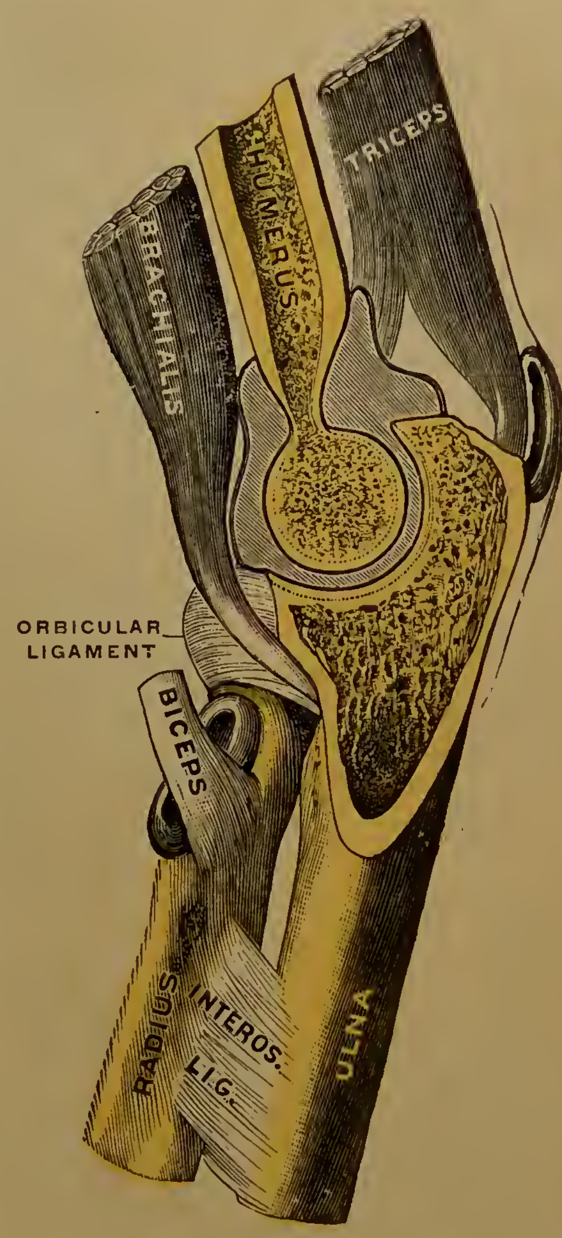

FIG. 263.—Elbow-joint in sagittal section, showing the articular synovial sac and the bursæ of the olecranon and the biceps. (Testut.)

(B) The **Middle Radio-ulnar Union** is accomplished by two ligaments. (1) The *oblique ligment* is a flattened band, which passes obliquely lownward and outward from the lower and outer oart of the tuberosity of the ulna, at the base of he coronoid process, to the radius, directly below nd behind the bicipital tuberosity. Below this ligament is a space through which the posterior nterosseous vessels pass. This space is bounded oelow by the strong (2) *interosseous membrane.* The fibres of the latter pass mostly obliquely downward and inward from the interosseous oorder of the radius, commencing about one inch oelow the tuberosity, to the whole length of the interosseous border of the ulna. A few fibres on its dorsal surface are parallel with the oblique ligament, decussating with the other fibres. The interosseous space is widest in the middle third, and is wider in supination than in pronation.

(C) The **Inferior Radio-ulnar Articulation,** between the sigmoid cavity of the radius and the lower end of the ulna, is separated from the wrist-joint by the *triangular fibro-cartilage.* This thick plate is the most important structure in this joint, not only as the strongest bond of union between the two bones, but also in limiting their movements. It is attached by its base to the margin of the radius, which separates the sigmoid cavity from the carpal facet, and by its apex to the fossa at the base of the styloid process of the ulna externally. This cartilage separates the lower end of the ulna, which rests on its upper smooth, concave surface, from the cuneiform bone of the carpus. Some scattered fibres from the two ends of the sigmoid cavity of the radius pass to the ventral and dorsal surfaces of the lower end of the ulna above its articular surface. They are called *anterior* and *posterior radio-ulnar ligaments,* and are connected with the borders of the fibro-cartilage inferiorly, and with the interosseous membrane superiorly, thus completing the *capsule.* Lining the capsule is the *synovial membrane,* which

is remarkably loose. Besides extending upward between the radius and ulna, it lines the upper surface of the fibro-cartilage beneath the latter.

The *nerve-supply* of the inferior radio-ulnar joint comes from the anterior and posterior interosseous nerves.

Movements.—The upper end of the radius rotates on a longitudinal axis passing through its head and neck, while the lower end rotates around the head of the ulna, having the attachment of the apex of the fibro-cartilage as its centre (Fig. 264). The entire bone thus describes rather less than 180° of a cone, with its apex above and its base below, its axis extending from the centre of the radial head to the outer side of the styloid process of the ulna. In these movements the radius carries the hand. The forearm is said to be supinated when its two bones lie nearly parallel and the dorsum of the hand looks backward, and pronated when the radius lies obliquely across the ulna, and the palm of the hand looks backward.

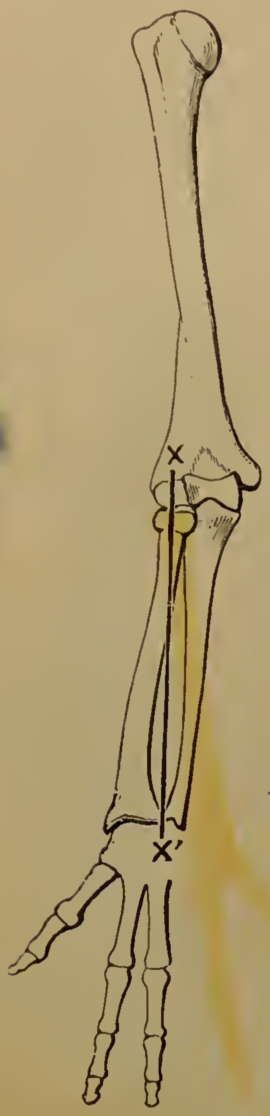

FIG. 264.—Mechanism of pronation and supination. (Testut.)

The power of supination is much greater than that of pronation. In the above movements the ulna is thought by many to undergo slight circumduction. This implies a little lateral movement at the elbow, which, if it occurs at all, must be very trifling and due to a slight incongruence of the surfaces. Supination and pronation with a straight arm are apparently much increased by the rotation of the humerus at the shoulder. The interosseous membrane, from the direction of its fibres, transmits the weight of the body from the ulna to the radius or the shock of a fall on the hands from the radius to the ulna.

6. The Wrist-joint or Radio-carpal Articulation (Figs. 265, 266).

The lower end of the radius and of the triangular fibro-cartilage presents a surface slightly concave transversely, as well as from before backward, which receives the correspondingly convex upper articular surfaces of the scaphoid, semilunar, and cuneiform bones. The latter surfaces are prolonged farther upon the dorsal than upon the palmar aspect. The ulna is excluded from the joint by the triangular cartilage; and the pisiform bone of the first row does not enter into the articulation. The joint is condyloid in action.

The rather loose *capsule* is described as four ligaments, which are, however, continuous. The *internal lateral ligament* is attached above as a rounded cord to the styloid process of the ulna, and spreads out below onto the cuneiform and pisiform bones. The *external lateral ligament* radiates from the summit of the radial styloid process onto the outer, back, and front surfaces of the scaphoid, some fibres being continued to the trapezium and os magnum. It is in relation with the radial artery and the extensor tendons of the thumb. The *anterior ligament* is broad, strong, and membranous. Its fibres pass for the most part obliquely from the anterior border of the lower end of the radius downward and inward to the palmar aspect of the scaphoid, semilunar, and cuneiform bones, especially the latter. Some fibres pass over to the os magnum. Another group of fibres passes more vertically from the ulnar styloid process to the semilunar and cuneiform bones. The *posterior ligament*, thinner and less strong than the anterior, is strengthened by the extensor tendons in relation with it. Its fibres also pass for the most part obliquely downward and inward from the dorsal border of the lower end of the radius to the first row of carpal bones, especially to the cuneiform bone.

The *synovial membrane* lines the capsule between the articular surfaces.

7. The Carpal Articulations.

The bones of each of the two rows of the carpus, exclusive of the pisiform, re connected together by *dorsal, palmar,* and *interosseous ligaments,* passing early transversely between adjacent bones. The palmar are stronger than the orsal ligaments.

The **Joint between the Pisiform and Cuneiform bones** is arthrodial, and has a thin,

FIG. 265.—The articulations of the carpus. The synovial sacs are represented as distended. (Testut.)

loose *capsule* lined by *synovial membrane* and strengthened by a fibrous band passing to the hook of the unciform, by another passing to the base of the fifth metacarpal, and by the insertion of the tendon of the flexor carpi ulnaris from above.

The Medio-carpal or Transverse Carpal Articulation.—This joint is between the lower aspect of the first carpal row, which is concave except for the convex outer part of the scaphoid, and the upper surface of the second carpal row, concavo-convex from without inward. It is united by *dorsal* and *palmar, internal* and *external lateral ligaments.* The *lateral ligaments,* prolonged from the lateral ligaments of the wrist-joint, connect the lateral surfaces of the outer and inner bones of the two rows. The *dorsal ligaments* extend obliquely between the dorsal surfaces of the bones of the two rows. The stronger *palmar ligaments* are composed of fibres which for the most part radiate from the os magnum to the bones of the upper row.

The *synovial membrane* is extensive. From the medio-carpal joint it sends two processes upward between the three bones of the upper row (exclusive of the pisiform); and between the four bones of the lower row it sends three processes downward, which are continued into the four inner carpo-metacarpal and the three intermetacarpal articulations. It is nearly always separated from that of the wrist by the interosseous ligaments which pass between the bones of the upper row, and make their convex upper surfaces uniformly even.

The *nerve-supply* of the radio-carpal and carpal joints is from the ulna and median in front and the posterior interosseous behind.

8. The Carpo-metacarpal and Intermetacarpal Articulations.

The proximal ends of the inner four metacarpal bones are united to the inner three bones of the lower row of the carpus by dorsal and palmar ligaments. Of the *dorsal ligaments* the second and third metacarpals receive two or three each, the fourth two, and the fifth one. The latter is continuous internally with the palmar ligament, forming a partial capsule between the unciform and the fifth metacarpal, open externally. The *palmar ligaments* are weaker and less defined;

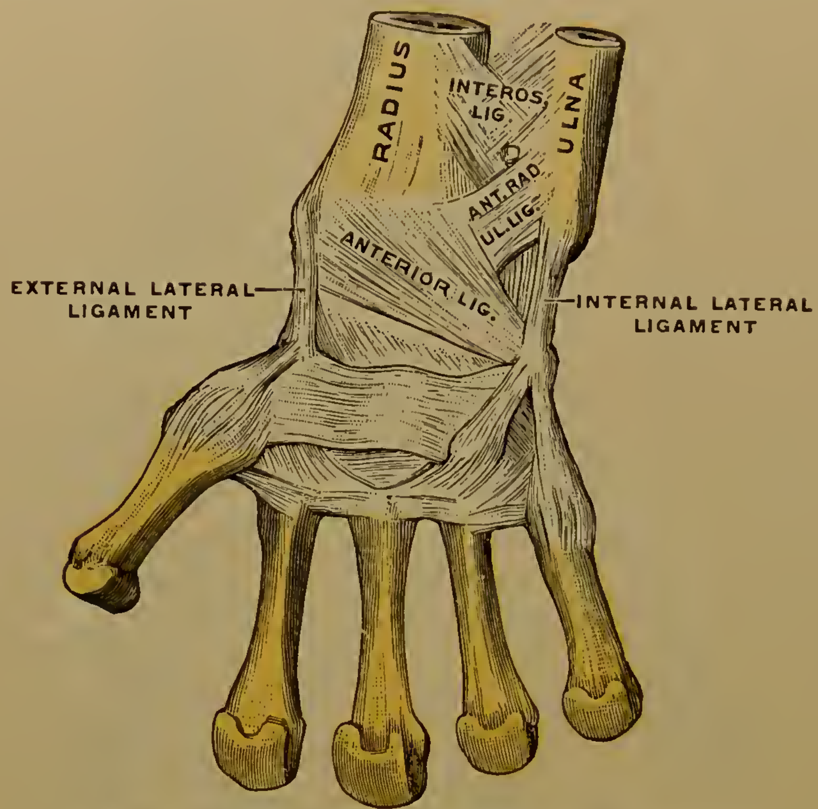

FIG. 266.—Ligaments of the carpus, front view. (Testut.)

the third metacarpal receives three, the others one each. An *interosseous ligament* also connects the contiguous lower angles of the os magnum and the unciform with the adjacent surfaces of the third and fourth metacarpals, occasionally shutting off the synovial sac between the inner two metacarpals and the unciform from the common synovial sac, which is continuous with that of the carpal joints. A strong band from the trapezium to the outer aspect of the base of the second metacarpal helps to close the radial side of the joint of the latter.

The bases of the inner four metacarpal bones are bound together by transverse, *palmar, dorsal* and *interosseous ligaments.* Their distal ends are united by transverse fibres passing between the margins of the palmar or glenoid ligaments of the metacarpo-phalangeal joints, and forming the *transverse metacarpal ligament,* which limits the separation of the metacarpal bones. The first metacarpal bone is free from the others at both ends. In the *carpo-metacarpal joint of the thumb* there is a thick, loose *capsule,* strongest dorsally and externally, which connects the margins of the articular surfaces of the trapezium and the first metacarpal. It is lined by a separate *synovial membrane.*

The *nerve-supply* of the inner four carpo-metacarpal joints comes from the deep palmar branch of the ulnar, the posterior interosseous, and the median, the last supplying also the first carpo-metacarpal joint.

Movements of a similar nature occur in the *radio-carpal* and *medio-carpal joints.* These movements are *flexion* and *extension, abduction* and *adduction,* and *circumduction.* Extension is more free than flexion in the radio-carpal joint, owing to the greater extent of the carpal articular surfaces dorsally than ventrally; but flexion is more free than extension at the medio-carpal and carpo-metacarpal joints, and it is the more free of the two motions in the wrist as a whole. Abduction and adduction, on an antero-posterior axis, occur principally at the radio-carpal joint. Adduction is much the more free, for the ulna does not extend as low as the

radius, and does not help the external lateral ligament to check adduction as the radius does the internal lateral ligament to check abduction. The lack of rotation in the wrist is compensated for by the pronation and supination of the forearm, in which the hand rotates with the radius. In the medio-carpal joint, besides very free flexion, moderately free extension, and slight lateral motion, there is very limited rotation of the head of the os magnum and the unciform in the socket formed by the upper row, while the trapezium and trapezoid glide back and forth on the scaphoid. In the central carpo-metacarpal joints flexion and extension are slight. The fifth metacarpal is capable of more flexion than are the second, third, and fourth, and this flexion is directed outward as well as forward, producing opposition, or narrowing and hollowing of the hand, as in the closed fist. The movements of the first metacarpal are regulated principally by the saddle-shape of the surfaces, and consist of flexion and extension, abduction and adduction, and circumduction. Flexion is most free, and occurs obliquely forward and inward, thus allowing the opposing of the thumb to any of the fingers. Abduction is also very free, adduction less so. Movements between bones of the same row in the carpus are limited to slight gliding, which gives elasticity to the carpus, breaks jars and shocks, and thus strengthens the wrist.

9. Metacarpo-phalangeal and Interphalangeal Articulations.

The cup-shaped bases of the proximal phalanges receive the rounded heads of the metacarpal bones to form a condyloid joint whose *capsule* is very weak behind, where the joint is covered by the expansion of the extensor tendons, but is reinforced laterally in front. The strong *lateral ligaments* are attached to the lateral tubercles and the depressions in front of them on the heads of the metacarpal bones, and pass downward and forward to the lateral margins of the bases of the phalanges and to the palmar or glenoid ligaments. The *anterior, palmar,* or *glenoid ligament* is a thick fibro-cartilaginous plate, attached closely to the phalanx, loosely to the metacarpal bone. It is continuous laterally with the lateral ligaments and the transverse metacarpal ligament. Its palmar surface is slightly grooved for the flexor tendons, the sheaths of which are attached to its margins. Its dorsal surface helps to support the head of the metacarpal bone. In the thumb (and occasionally elsewhere) the fibro-cartilage ossifies into two sesamoid bones which receive the insertion of the short muscles and form a groove for the long flexor muscle.

The *interphalangeal articulations* are in every way similar, except for slight differences in the shape of the articular surfaces, which influence the action. A *synovial membrane* lines the inner surface of the connecting ligaments of each joint.

The *nerve-supply* comes from the digital branches.

Movements.—In the metacarpo-phalangeal joint of the thumb motion is limited to flexion and extension, owing to the width of the surfaces. In the four other fingers abduction and adduction, in relation to the middle finger as the axis, are also quite free in the extended position. Flexion is the freest movement, owing to the greater extent of the articular facet in front and to the forward obliquity of the lateral ligaments. Flexion to a right angle and extension to a little beyond a straight line are permitted. Although abduction and adduction may occur separately, flexion and adduction and extension and abduction are associated together. The movements in the interphalangeal joints are limited to flexion and extension. Flexion is the more free for the same reason as above given, and in the proximal joint it exceeds a right angle; in the distal joint it may be rather less. The greater freedom of the thumb is due to the motion in the carpo-metacarpal rather than in the lower joints.

THE ARTICULATIONS OF THE PELVIS (Figs. 267, 268).

The Articulations of the Pelvis with the Last Lumbar Vertebra.

The fifth lumbar is united to the first sacral vertebra by such joints and ligaments as are found between the vertebræ above, with the addition of two special accessory ligaments on each side, as follows: The *lumbo-sacral ligament* is a strong, triangular band, with its apex above and internally, where it is attached to the lower and front part of the transverse process of the last lumbar vertebra, from which it radiates downward and outward to the ala of the sacrum and the adjacent part of the ilium. It blends with the anterior sacro-iliac ligament below and with the ilio-lumbar ligament above. The *ilio-lumbar ligament* also is a strong triangular band, which passes from the apex of the transverse process of the fifth lumbar vertebra outward and somewhat backward, expanding to its attachment along the dorsal two inches of the inner lip of the iliac crest. It represents the thickened lower edge of the ventral layer of the lumbar fascia covering the quadratus lumborum, and gives origin to that muscle. It also helps to complete the dorsal boundary of the false pelvis.

The Sacro-coccygeal and Intercoccygeal Articulations.

The sacrum is united to the coccyx by an oval *intervertebral disc*, by an *anterior* and a stronger *posterior sacro-coccygeal ligament*, the continuations of the anterior and posterior common ligaments of the vertebræ; and by *lateral ligaments* passing between the cornua of the two bones, and between the transverse processes of the first coccygeal vertebra and the lateral angles of the sacrum. The ligaments connecting the cornua of the two bones are sometimes called *inter-articular*, as the cornua represent articular processes; but the ligament is probably the continuation of the supraspinous ligament, which roofs over the lower end of the spinal canal.

The *nerve-supply* is derived from the fourth and fifth sacral and coccygeal nerves.

The several pieces of the coccyx are held together by the continuation of the anterior and posterior ligaments described above. Small discs of fibro-cartilage also connect them as long as they remain separate bones.

The Sacro-iliac Joint.

This is a synchondrosis in which the cartilage-clad auricular surfaces of the sacrum and ilium are bound together by a thin stratum of softer fibro-cartilage, which may contain a synovial-like cavity. In some cases also interosseous fibrous tissue partly binds the surfaces together, especially near the dorso-superior border, behind and above which the short transverse fibres of the deep part of the posterior sacro-iliac ligament sometimes receive the name of *interosseous ligament*.

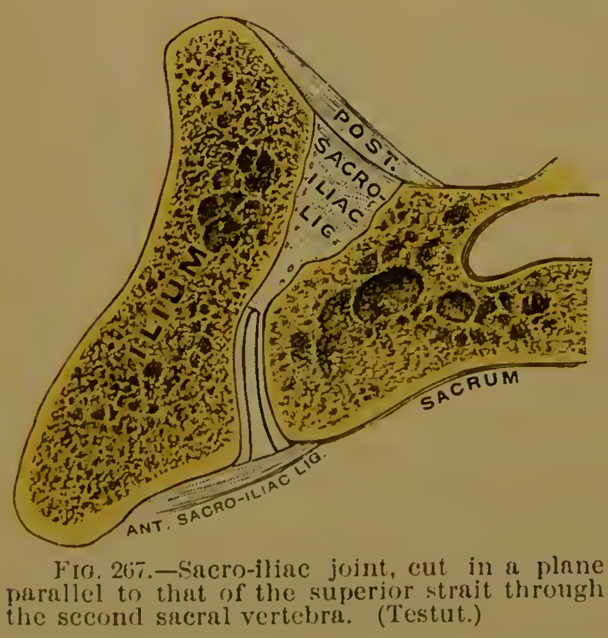

FIG. 267.—Sacro-iliac joint, cut in a plane parallel to that of the superior strait through the second sacral vertebra. (Testut.)

The *anterior sacro-iliac ligament* consists of a thin layer of fibres covering the front or pelvic surface of the joint, between the pelvic brim and the great sacro-sciatic notch. The *posterior sacro-iliac ligament* is very strong. The deeper bundles of fibres pass inward and slightly downward from the rough area above and behind the auricular surface of the ilium to the back of the lateral mass of the sacrum. A more dorsal or superficial band, sometimes called the *long or oblique sacro-iliac ligament*, passes from the back of the posterior superior iliac

spine downward and slightly inward to the back of the third sacral vertebra. The cartilage connecting the auricular surfaces of this joint tears away, as one mass, from one or the other surface when the bones are forcibly separated. The *nerves* supplying the joint come from the superior gluteal and external branches of the posterior divisions of the first and second sacral nerves. The sacro-sciatic ligaments also help to support this joint.

The *great* or *posterior sacro-sciatic ligament* is thin and flat at its attached ends, narrower and thicker in the centre, which thus divides it into two triangles, of which the broader is attached to the posterior inferior iliac spine and the sides of the sacrum and coccyx, and the narrower to the inner margin of the ischial tuberosity, sending its *falciform process* along the inner margin of the ischial ramus. The free, sharp edge of the falciform process is continuous with the posterior border of the ligament and with the obturator fascia. Some fibres pass over the tuberosity into the tendon of the biceps, of which this ligament represents the proximal continuation. The direction of this ligament is from above downward, outward, and slightly forward. It assists in bounding the pelvic outlet and the perineum laterally, and between it and the hip-bone is a large space subdivided by the *small* or *anterior sacro-sciatic ligament* into the *great sacro-sciatic foramen*

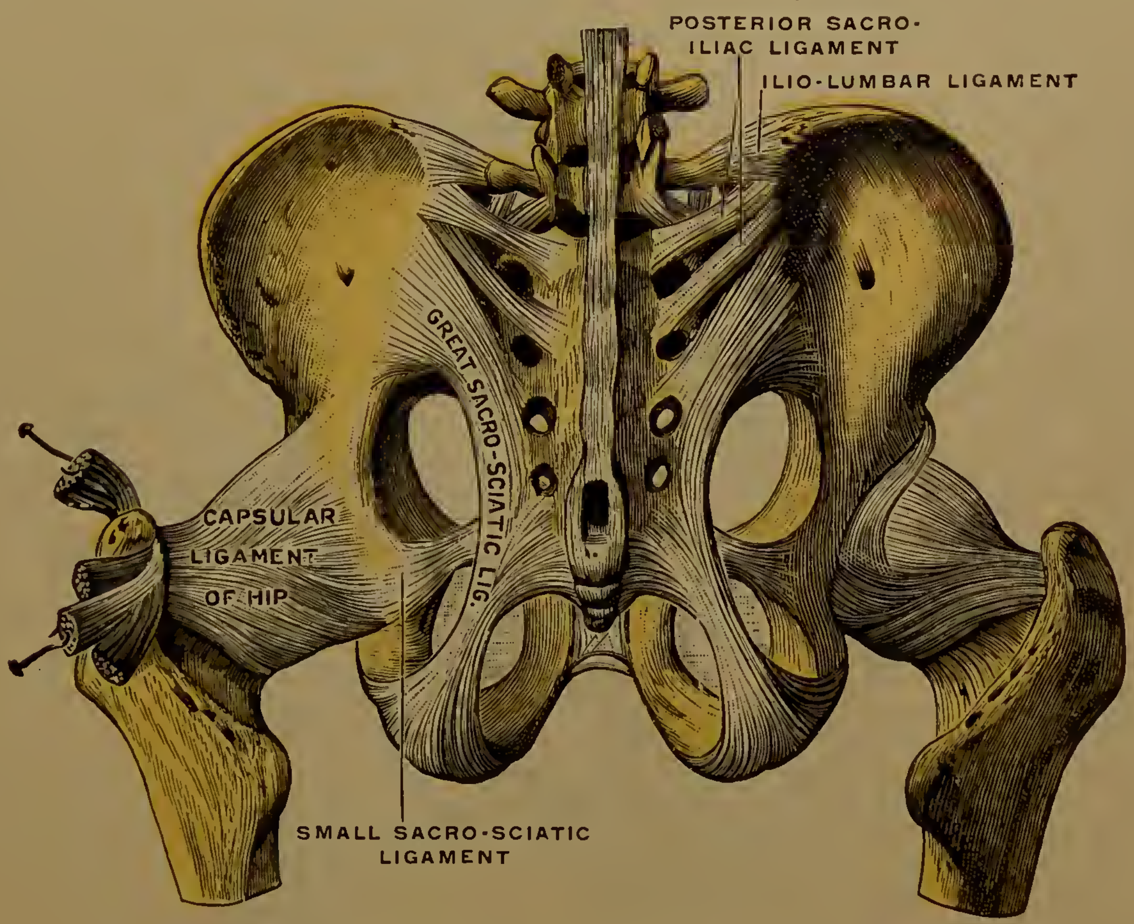

FIG. 268.—Articulations of the pelvis, rear view. (Testut.)

above and the *small sacro-sciatic foramen* below. This ligament lies in front of the preceding, and is triangular in form, its wide base attached to the side of the sacrum and coccyx, its apex to the ischial spine. Its deep surface is closely connected with the coccygeus muscle, of which it represents the thickened sheath. Through the great sacro-sciatic foramen pass the pyriformis muscle, and above the muscle the gluteal vessels and superior gluteal nerve, below the muscle the sciatic and internal pudic vessels and nerves, the inferior gluteal nerve, and the nerves to the obturator internus and quadratus femoris muscles. The small sacro-sciatic foramen is the smaller space below the small sciatic ligament. It is bounded behind by the great sacro-sciatic ligament and in front by the smooth cartilage-clad surface between the ischial spine and tuberosity, over which passes the obturator internus muscle. The internal pudic vessels and nerve and the nerve to the obturator internus pass in through this foramen.

The Symphysis Pubis.

The opposed median surfaces of the pubic bones are each covered with a thin layer of hyaline cartilage, united into a single *interpubic disc* by an interposed layer of fibro-cartilage. The latter is broader in front and below, and bulges especially behind. It is attached to the surrounding ligaments on all sides, and often contains a cleft. This cleft or cavity is usually nearer the upper and back part, it does not reach the surface, nor is it lined by synovial membrane, and it is larger in the female, though not greatly affected by pregnancy. A fibrous *capsule* surrounds the joint, which is further strengthened by tendinous attachments. The *superior* and *posterior ligaments* are but slightly marked transverse fibres strengthening the periosteum. The *anterior ligament* is stronger, and consists of deep transverse fibres and superficial oblique, decussating fibres connected with the tendons of the muscles arising from the body of the os pubis. The *inferior* or *subpubic ligament* is a thick triangular mass of transverse and curved fibres, rounding off the subpubic angle of the pubic rami, which forms the ventral angle of the pelvic outlet.

Movements, Mechanism, etc.—Owing to the thickness of the disc between the fifth lumbar vertebra and the sacrum, movements are more free here than between any two lumbar vertebræ, and especially flexion and extension, which occur in sitting or in rising from the sitting posture. The inclination of the pelvis depends partly upon the sacro-vertebral angle between the sacrum and the spine, but also, and in great part, on the obliquity of the hip-bones to the sacrum at the sacro-iliac joint. At the sacro-iliac joint there is no movement: it merely serves to break shocks. In the erect position the base of the sacral wedge is directed so largely forward, and the ventral or broader surface of the sacrum is directed so largely downward, that the sacrum is not held in place by virtue of its wedge shape, but is suspended from the ilia by the very strong posterior sacro-iliac ligaments in such a way that the greater the pressure the tighter is the union. The tendency to rotation of the sacrum, due to the weight of the spine transmitted to its forward projecting base, is resisted above by the ilio-lumbar and below by the sacro-sciatic ligaments (the former directed backward, the latter forward from the sacrum). At the pubic symphysis there is only a slight yielding of the cartilage, which may occur at childbirth, when the cartilage is softer and more vascular; but the decussating tendinous fibres of the abdominal muscles, which cross it in front, would tend to brace the bones more tightly together by their contraction during labor. The sacro-coccygeal joint allows of flexion and extension. In defecation and parturition the coccyx is pushed backward. This joint may be ankylosed in adult life, but less often in females than in males, and its mobility seems to increase during pregnancy.

THE ARTICULATIONS OF THE LOWER LIMB.

1. The Hip-joint (Figs. 269–271).

In this typical ball-and-socket joint the round head of the femur is received into the acetabulum of the hip-bone. The cartilage-clad surface of the acetabulum is horseshoe-shaped, broader above and behind, and deficient below at the cotyloid notch and in the depression at the bottom of the acetabulum, which is occupied by a mass of fat covered by synovial membrane—the so-called *synovial* (Haversian) *gland*. The articular cartilage of the head of the femur is thicker above, where it bears the weight of the body, and is wanting a little behind and below the centre, at the depression for the ligamentum teres. The acetabular rim is completed below by the transverse and decussating fibres of the *transverse ligament*, which bridges over the cotyloid notch, and converts it into a foramen through which articular vessels pass. This ligament blends with and helps to support the *cotyloid ligament*, a thick fibro-cartilage, triangular on section, firmly

attached by a broad base to the rim of the acetabulum, which it deepens to more than a hemisphere. Its concave inner surface and thin free margin tightly embrace the head of the femur a little beyond its greatest circumference and, aided by atmospheric pressure, hold it in place when the capsule is divided. Its fibres pass obliquely from without inward, and its outer convex surface is in contact with the capsular ligament. It is covered on both sides by synovial membrane.

The *capsular ligament* is one of the strongest in the body. Surrounding the joint, it is attached to the pelvis at or near the rim of the acetabulum, outside of the cotyloid ligament, and to the transverse ligament. On the femur it is attached in front to the anterior intertrochanteric line, from the tubercle above to the level of the lower part of the small trochanter below. From the latter point its line of attachment passes upward and backward, above the small trochanter, and thence upward and outward on the posterior surface of the neck, one-half to two-thirds of an inch internal to the posterior intertrochanteric line or at the junction of the middle and outer thirds of the neck. Superiorly it is attached at the base of the great trochanter, internal to the

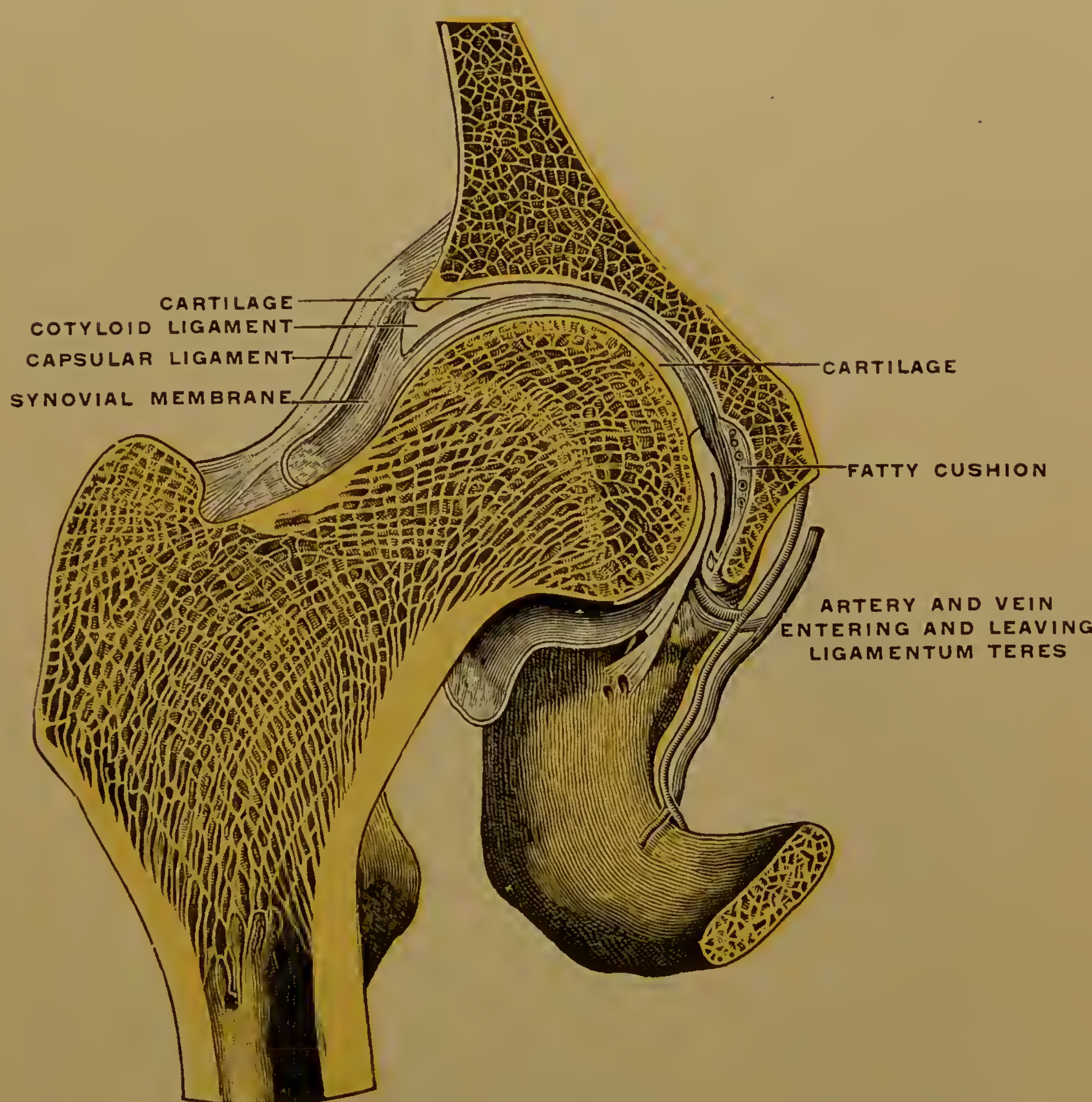

FIG. 269.—Hip-joint in coronal section. (Testut.)

digital fossa. The innermost capsular fibres are reflected upon the neck of the femur toward the articular margin, blending with the periosteum and forming three flat bands or *retinacula*, one behind and one at either end of the anterior intertrochanteric line. The capsule is somewhat loose, and its fibres run longitudinally with some circular fibres interwoven. The circular fibres are found most abundantly behind and below, where they form a band arching around the neck of the femur. The longitudinal fibres are much thickened in parts by *accessory bands*, inseparable from the capsule, which greatly strengthen the joint. Many of these bands are derived from the fascial sheaths of the surrounding muscles, which are—in front, the ilio-psoas, partly separated from the capsule by a bursa; internally, the pectineus; below and behind, the obturator externus; behind, the obturator internus with the two gemelli and the pyriformis; above or externally,

the rectus femoris and the gluteus minimus. The obturator internus acts like a powerful strap at the back of the joint.

Of the three principal accessory bands, the *ilio-femoral band* is the strongest and most important. Superiorly it is attached to the ilium, below and behind the anterior inferior spine; inferiorly it spreads out triangularly to the anterior intertrochanteric line of the femur. Its inner and outer borders form two very strong bands, between which the capsule is thinner, so as sometimes to suggest the name of the inverted Y-ligament given it by Bigelow. This ligament is rarely torn, and forms the fulcrum for the manipulation in reducing dislocations of the thigh. The outer or upper part of this band, passing to the upper end of the anterior border of the great trochanter, is sometimes described as the *ilio-trochanteric ligament.*

The *pubo-femoral band* is the weakest, and passes from an area between the pectineal eminence and the cotyloid notch to the neck of the femur, above and behind the inner band of the ilio-femoral ligament. It is derived from the fascia between the pectineus and the obturator externus. The capsule is thinnest between this and the ilio-femoral band, where it is perforated by an opening between the synovial cavity and the bursa beneath the psoas. The *ischio-femoral band* consists of strong fibres arising from the ischium just below the acetabulum, which curve upward and outward to the base of the great trochanter internal to the digital fossa. When the thigh is flexed their direction is almost straight from their ischial to their femoral attachment. The capsule is weak dorsally below this band, where it usually tears in dislocation. Between this and the ilio-femoral band superiorly the capsule is strong, and is further strengthened by bands from the gluteus minimus and from the reflected tendon of the rectus. From the latter the *tendino-trochanteric band* passes to the upper end of the vastus externus muscle.

FIG. 270.—Hip-joint, front view. The cavity is distended artificially. (Testut.)

The *ligamentum teres* (round ligament) is not round, but a triangular, flat interarticular band attached by its apex to the upper half of the depression on the head of the femur, and by its base to the transverse ligament and the margins of the cotyloid notch, the ischial portion being the stronger. It is surrounded

by synovial membrane, and represents a migrated portion of the pectineus muscle. It conveys a small branch of the obturator artery to the head of the femur. It is torn in dislocation of the femur.

The *synovial membrane* lines the inner surface of the capsule, from which it is reflected onto the neck of the femur as far as the articular margin, and onto the two free surfaces of the cotyloid ligament, thence being continued to the pad of fat at the bottom of the acetabulum, and as a tubular covering of the ligamentum teres.

Nerves.—The obturator, accessory obturator, anterior crural, and great sciatic or some other branch of the sacral plexus supply the joint.

Movements.—All the movements of a ball-and-socket joint are permitted. The obliquity of the neck of the femur allows flexion and extension to take place by a rotation of the head without its cartilage-clad surface leaving the socket, thus securing strength for these, the most important movements. Extension is limited by the strong ilio-femoral band, which helps to maintain the erect position without muscular exertion by preventing over-extension in standing, for in this position the centre of gravity descends behind the centre of the joint and tends to hyperextend it. Flexion takes place through about 140°, until checked by the contact of the thigh and abdomen if the knee is flexed; otherwise, it is checked

FIG. 271.—Hip-joint, front view. The capsular ligament has been largely removed. (Testut.)

at about 90° by the hamstring muscles. In all the other movements the articular portion of the head projects beyond the cotyloid rim on the side opposite to that toward which the movement takes place. Abduction is limited by the pubo-femoral band, adduction by the outer part of the ilio-femoral band and the upper part of the capsule. Rotation takes place on a vertical axis passing from the head above to the lower extremity of the femur below. This axis is not coincident with that of the shaft. Inward rotation is limited by the ischio-femoral band, outward rotation by the ilio-femoral band (its inner part during extension, its outer during flexion). The ligamentum teres is put on the stretch in flexion with abduction or outward rotation, or both, but it is too weak to be of use in resisting these movements or in strengthening the joint.

2. The Knee-joint (Figs. 272–275).

This, the largest joint in the body, is a modified hinge-joint, whose bony articular surfaces (the condyles and trochlear surface of the femur, the tuberosities of the tibia and the patella) are not well adapted to one another except by means of soft parts and the interposed fibro-cartilages. The knee is very superficial, and is strong only by reason of the number and strength of the ligaments and surrounding tendons and muscles, which, as well as the width of the bony surfaces, resist dislocation in spite of the leverage above and below it of the two longest bones in the body. It represents two morphologically distinct joints, the patello-femoral and the tibio-femoral, the latter also composed of two laterally placed joints, the median division between which is represented by the crucial and mucous ligaments. The synovial membrane of these joints has blended into one. The *fibrous capsule* of the knee is strengthened in places by strong bands derived from the surrounding tendons, closely adherent to its outer surface, and known as the *external* (superficial) *set of ligaments.*

1. The *internal lateral ligament* is a long, flat, strong band which extends from the internal tuberosity of the femur, close to the adductor magnus tendon (of which it was originally a continuation), to the inner surface and inner border of the tibia, on which it descends below the level of the tubercle. Superiorly it is blended on its deep surface with the fibro-cartilage and capsule, but is separated from the latter below, where it bridges over part of the semimembranosus tendon and the inferior internal articular vessels. Superficially, it is separated by a bursa from the tendons of the sartorius, gracilis, and semitendinosus.

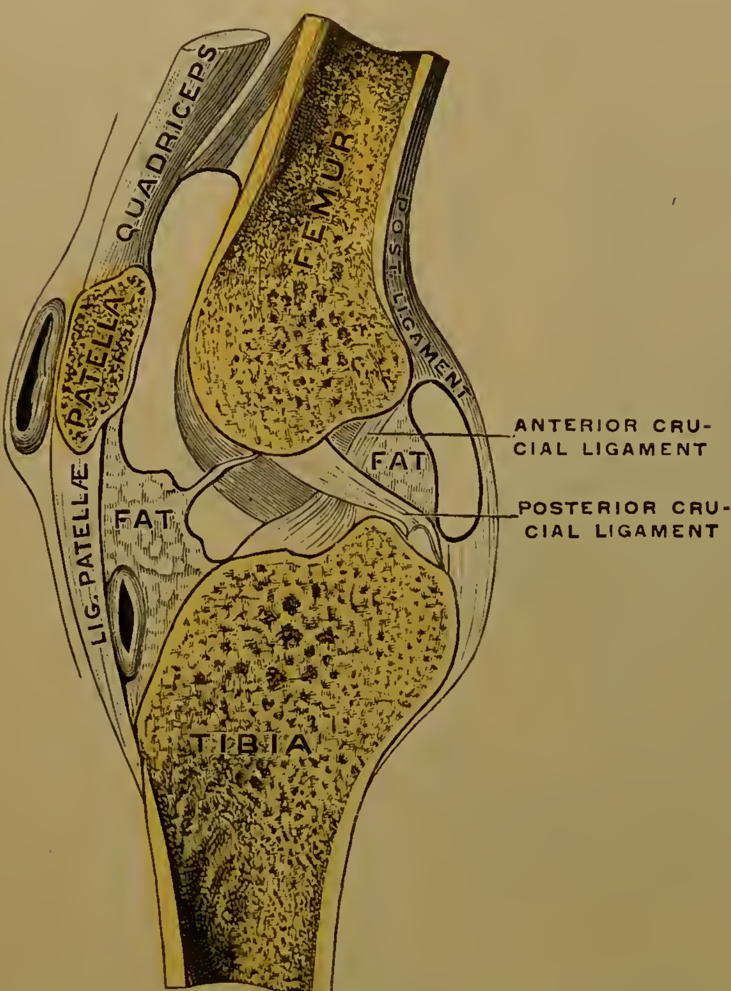

Fig. 272.—Knee-joint in sagittal section. (Testut.)

2. The *external lateral ligament* extends downward and slightly backward as a rounded cord from the external tuberosity of the femur to the middle of the outer surface of the head of the fibula. It crosses over the popliteus tendon and the external inferior articular vessels, and is separated by a bursa from the biceps tendon, which splits to embrace it. It is continuous below with the origin of the peroneus longus, of which it represents the detached femoral origin. A little behind this ligament is the broader but less constant and less well defined *short* or *posterior external lateral ligament.* This extends from the external condyle of the femur, in connection with the external gastrocnemius tendon, to the styloid process of the fibula. It blends with, and is really a portion of, the posterior ligament. Both internal and external lateral ligaments are situated behind the centre of the joint.

3. The *posterier ligament* proper is a strong flat band which ascends obliquely upward and outward as an expansion from the semimembranosus tendon, from the back of the inner tuberosity of the tibia, to the external condyle of the femur, joining the outer head of the gastrocnemius. The rest of the so-called posterior ligament underlies this oblique portion, and is that part of the capsule which occupies the interval between the lateral ligaments behind. It is a broad membrane com-

posed of nearly vertical bundles of fibres, which pass from the upper margins of the intercondylar notch and of the articular surfaces of the femur to the dorsal margin of the head of the tibia.

4. The *ligamentum patellæ* is the strong, flat infrapatellar tendon of the quadriceps extensor, extending from the apex and lower border of the patella to the lower part of the tubercle of the tibia (where it descends lower on the outer side). A *synovial bursa* separates the ligament from the upper part of the tubercle, above which a mass of fat separates it from the synovial membrane.

5. The *capsular ligament* is seen only in the intervals between the above ligaments. Behind it is thickened to form most of the posterior ligament, in front it is wanting beneath the patella and its tendons, between which and the lateral ligaments it is strengthened by the fascia lata and the lateral fibrous expansions of the quadriceps extensor tendon. These expansions, passing down from the vasti muscles, are attached to the sides of the patella[1] and the ligamentum patellæ, and to the tibia along the oblique lines extending from the tubercle to the inner and outer tuberosities. They reach as far laterally as the lateral ligaments. Externally, the ilio-tibial band of the fascia lata, attached to the external one of the above oblique lines, adds largely to the strength of the capsule. The capsule is therefore made up of two or three layers, and between the deeper layer, or the capsular mem-

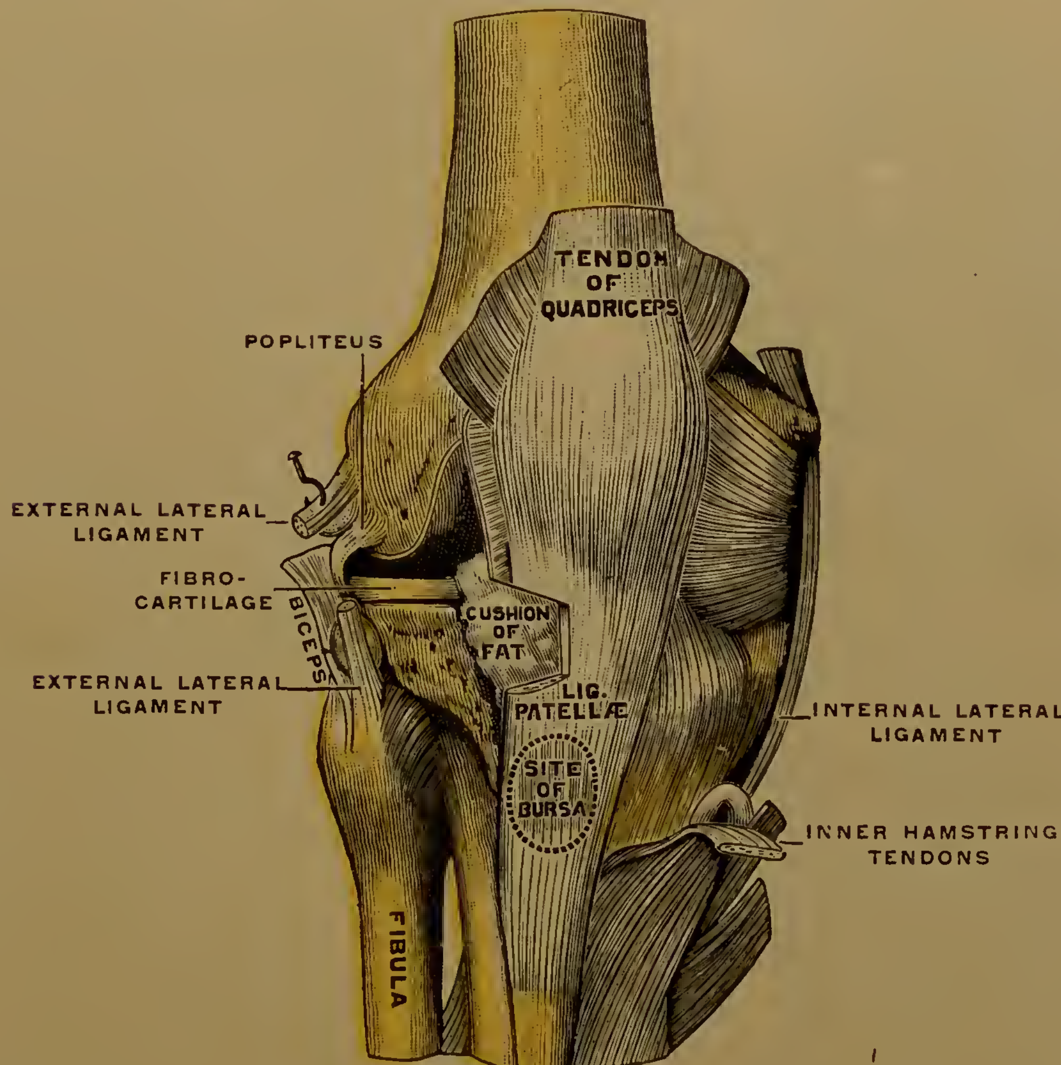

FIG. 273.—Knee-joint, front view. Part of the ligaments have been removed on the right side. (Testut.)

brane proper, and the outer layers there often exists a thin layer of fatty tissue. The capsular membrane is attached to the femur and tibia not far from their articular margins, and is adherent to the semilunar cartilages.

Of the so-called *internal* (deep) *set of ligaments*, most may be well seen by dividing the quadriceps tendon above the patella, continuing the section laterally and downward to the lower ends of both lateral ligaments, and turning down the flap thus made.

6. *Synovial Ligaments.*—From the synovial membrane lining the pad of fat behind the ligamentum patellæ two thin lateral folds of membrane extend upward,

[1] Forming what has been called the *lateral patellar ligaments*.

one on each side of the patella, known as the *alar ligaments*. From the middle of the surface of the pad a flattish fold, the *ligamentum mucosum*, extends backward and upward to the front of the intercondylar notch. It represents the remains of the synovial partition between the two halves of the tibio-femoral joint and between the patello-femoral and tibio-femoral joints.

On dividing the ligamentum mucosum we see

7. The *anterior crucial ligament*, which extends upward, backward, and outward from its lower attachment on the inner half of the depression in front of the spine of the tibia, and between the fore ends of the semilunar cartilages, to the dorsal part of the inner surface of the outer condyle of the femur.

8. The *posterior crucial ligament* is stronger, shorter, and more vertical than the anterior. From behind the tibial spine, from the popliteal notch, and receiving fibres from the posterior cornu of the external semilunar cartilage, its fibres ascend slightly forward and inward to the front of the outer side of the internal condyle of the femur. Behind and below it is adherent to the posterior ligament. It crosses the anterior crucial ligament on its inner side, and is blended with it below, but separated from it above by a V-shaped space. The synovial membrane is prolonged over them both.

The *external* and *internal semilunar fibro-cartilages* are two crescentic plates, of a dense, compact structure, attached by their thick, convex, outer surfaces to the inside of the capsule. They rest upon the circumferential portions of the upper articular facets of the tibia, covering a little less than two-thirds of these surfaces. They increase the concavity of these surfaces for articulation with the femur by a gradual thinning to their concave, free inner borders. Their upper, concave, femoral, and lower flattened tibial surfaces are free and covered by synovial membrane. They taper to their attached ends or *cornua*, which are purely fibrous, and are fastened in front of and behind the tibial spine, the cornua of the external cartilage being within those of the internal. The external semilunar cartilage is therefore more circular, the internal is more oval and longer from before backward.

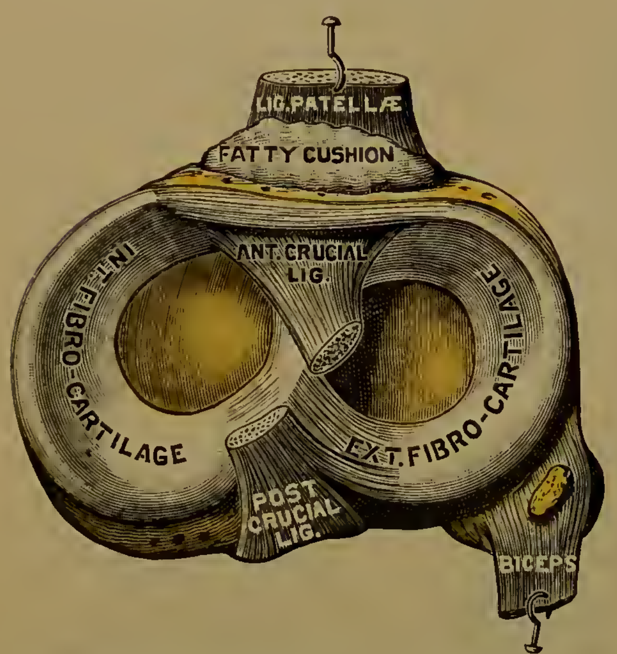

FIG. 274.—The semilunar cartilages of the right knee-joint. (Testut.)

The external is also more movable, from the close approximation of its cornua and from the greater laxity of the part of the capsule to which it is attached. Its outer surface is grooved behind, and separated from the capsule by the popliteus tendon, the bursa surrounding which connects with the joint above and below the cartilage.

The *transverse ligament* is a variable transverse band which connects the outer surfaces of the two semilunar cartilages in front.

Coronary ligament is a name applied to that part of the capsule between its attachment to the semilunar cartilages above and the head of the tibia below, which holds the cartilages in apposition with the tibia.

The *synovial membrane*, the largest in the body, lines the capsule of the joint. Above the patella, in front of the femur and beneath the extensor tendon, it forms a large pouch, communicating in most cases with a *bursa* above it. The latter lies between the extensor tendon and the front surface of the femur, above the attachment of the capsular membrane. Traced downward, the synovial membrane is found to line the capsule until it meets the semilunar cartilages, where it is reflected onto their upper surfaces, around their free inner margins, onto their lower surfaces, and so back to the portion of the capsule called the coronary ligament, which it lines down to its tibial attachment. From the capsule behind and

the semilunar cartilages below this membrane is reflected onto the crucial ligaments, which it invests, except behind and below, and thus shuts them out of the synovial cavity. It also forms the alar and mucous ligaments. *Synovial bursæ* beneath and between the gastrocnemius and semimembranosus internally, and beneath the popliteus tendon externally, may connect with the synovial cavity.

The *nerve-supply* comes from the internal and external popliteal, the anterior crural, and the obturator nerves.

Movements.—The principal movements are those of flexion and extension, which result from a combination of gliding and hinge-movement. This does not take place on a fixed axis, but on one which shifts with the points of contact from behind forward in extension, and *vice versa* in flexion. The points of contact of the articular surfaces are constantly changing from the flattened lower surface of the femoral condyles in extension to their more sharply curved dorsal surfaces in flexion, and from the fore part of the tibial surfaces in extension to their hind part in flexion. The looseness of attachment of the semilunar cartilages allows them to adapt themselves to the differently curved surfaces of the femur.

As the knee is moved from the flexed to the extended position the crucial ligaments become tense, and keep pulling back the articular surface of the tibia, so that the points of contact of both tibia and femur are shifted forward. This relaxes the ligaments and allows the motion to continue. The anterior crucial ligament also resists the tendency of the extensor muscle to displace the tibia forward in extension. In flexion the crucial ligaments cause a shifting of the points of contact in the opposite direction, and the posterior crucial ligament prevents the tibia from being pulled backward by the flexor muscles.

FIG. 275.—Knee-joint, outer side. The synovial sacs are artificially distended. (After Poirier.)

At the end of extension there is a slight outward rotation of the tibia and foot on a vertical axis, and at the commencement of flexion a slight rotation in the opposite direction. This is due in part to the greater length of the inner condyle, onto the outwardly directed fore part of whose articular surface the inner facet of the tibia glides forward in outward rotation at the end of extension, and backward in inward rotation at the beginning of flexion. Extension is checked by the lateral and posterior ligaments and the anterior crucial ligament. Flexion is checked by contact of the soft parts at about 135°. In extreme flexion the ligamentum patellæ, the fore part of the capsule, and the posterior crucial ligaments are tightened. The relaxation of the ligaments in the partly flexed position allows an inward and outward rotation, on a vertical axis, in which the semilunar cartilages slide back and forth on the tibia. This rotation is impossible in the extended position owing to the tension of the ligaments. Rotation inward is checked by the anterior crucial ligament, rotation outward by the lateral ligaments. The erect position, in which the line of gravity descends in front of the knee and tends to hyperextend it, is maintained, in great measure, without muscular effort by the resistance offered to over-extension by most of the ligaments.

The movements between the patella and the femur are a combination of sliding and coaptation. In moving from the extended to the flexed position the lower, middle, and upper parts of the patellar facets are successively in contact with the

upper, middle, and lower parts of the trochlear surface of the femur. In extreme flexion a narrow vertical surface on the inner side of the patellar facet is in contact with the fore part of the outer border of the inner condyle of the femur, the patella being turned more outward by the external condyle, against which its upper and outer part rests.

3. The Tibio-fibular Union.

The tibia and fibula are united at their upper and lower ends by joints, and between them by an interosseous membrane.

A. **The Superior Tibio-fibular Articulation.**—In this joint the oval, flattened, oblique articular surface on the head of the fibula is connected with that on the external tuberosity of the tibia by a *capsular ligament,* strengthened in front and behind by fibres which pass downward and outward from the tibia to the fibula—the *anterior* and *posterior superior tibio-fibular ligaments.* The capsule is not infrequently imperfect above and behind, where the synovial cavity of this joint may communicate with that of the knee through the medium of the bursa beneath the popliteus tendon.

B. The **Interosseous Membrane** extends between the outer border of the tibia and the interosseous border of the fibula as a firm aponeurotic membrane, whose fibres descend for the most part from the tibia to the fibula, with a few in the opposite direction. It is separated from the superior tibio-fibular joint by an oval opening through which the anterior tibial vessels pass, and below it is continuous with the inferior interosseous ligament, being perforated by the anterior peroneal vessels. It serves mainly for muscular attachment.

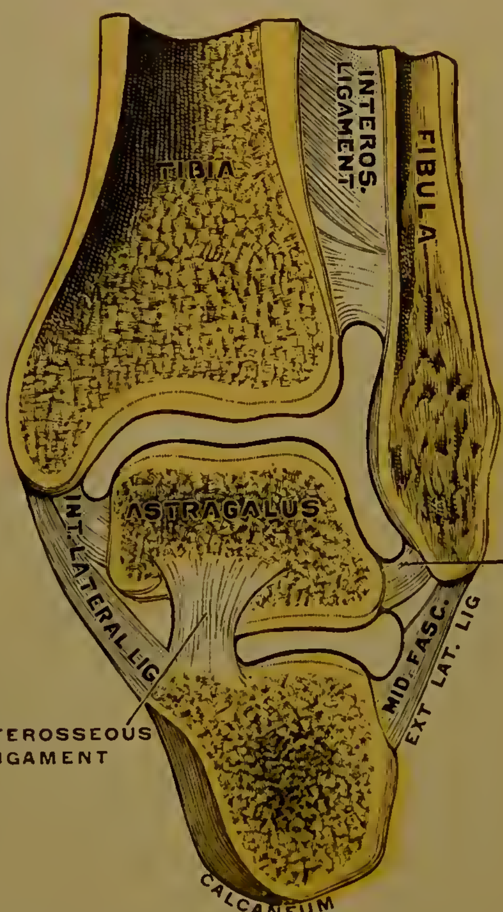

FIG. 276.—Tibio-tarsal and calcaneo-astragaloid articulations, in coronal section. The synovial sacs are distended. (Testut.)

C. **The Inferior Tibio-fibular Articulation** (Fig. 276).—The rough triangular surfaces on both bones, formed by the bifurcation of their interosseous borders, are firmly united by the short, strong, obliquely transverse fibres of the *inferior interosseous ligament,* to within a quarter of an inch of the facets for the astragalus, where two narrow articular facets, continuous with those for the astragalus, are in contact. The union is strengthened in front and behind by the *anterior* and

posterior inferior tibio-fibular ligaments, flat bands which extend across the joint from the lower end of the tibia obliquely outward and downward to the lower end of the fibula.

The *transverse ligament* is a thick, strong band, below the posterior ligament, which extends from the posterior border of the lower articular surface of the tibia outward, downward, and a little forward to the inner surface of the external malleolus, in and above the fossa. The *synovial membrane*, continuous with that of the ankle, extends up between the bones in front and behind as far as the inferior interosseous ligament.

The *movements* in these joints consist in a slight yielding or vertical sliding, which is allowed by the obliquity of the ligaments. The upward sliding of the fibula is accompanied by a slight widening of the tibio-fibular mortice, which occurs in flexion of the ankle. The inferior interosseous ligament is put to a great strain in the injuries producing "Pott's fracture."

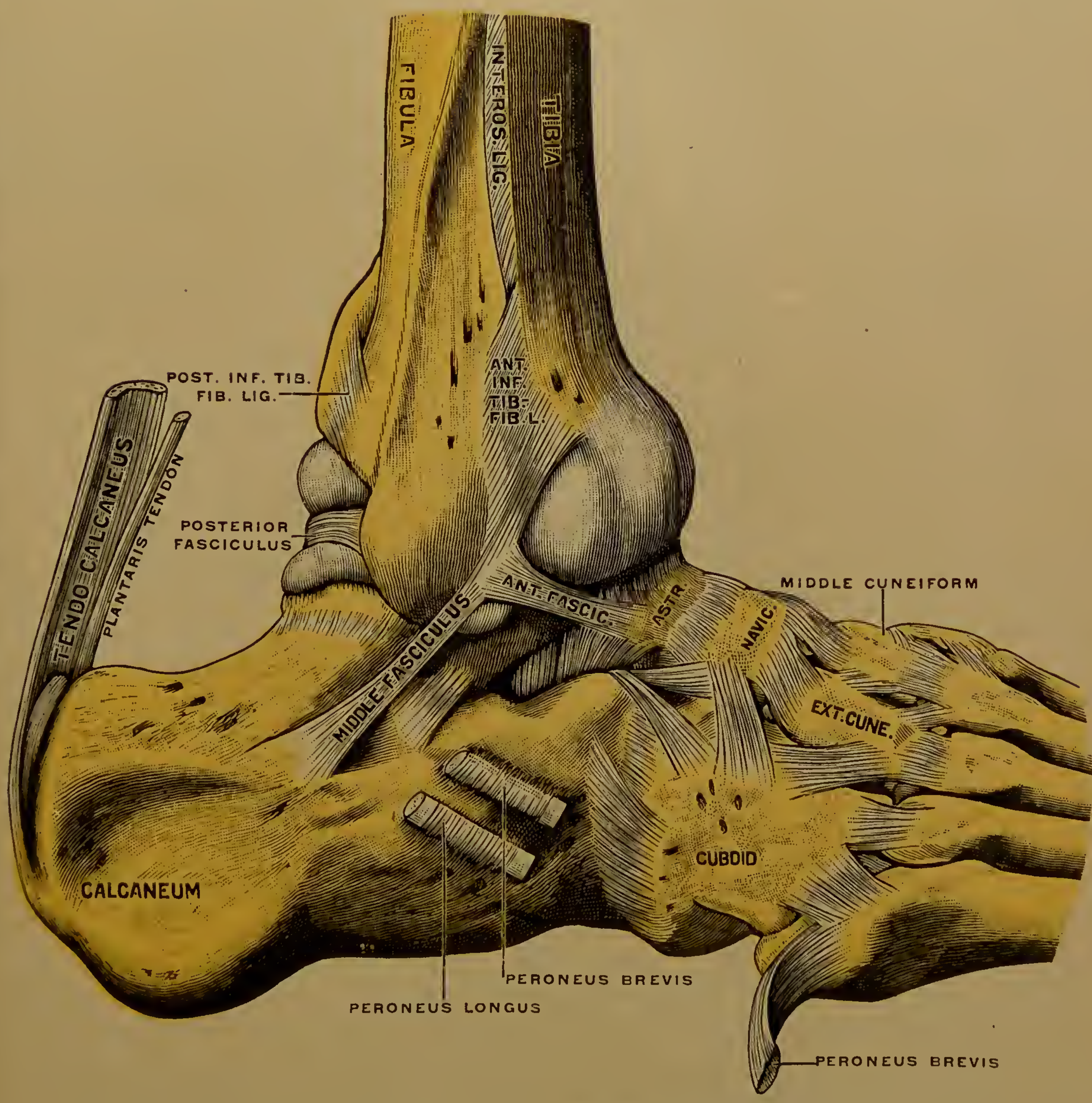

FIG. 277.—Tibio-tarsal articulation, outer side. The cavity is artificially distended. (Testut.)

4. **The Ankle-joint** (Figs. 277, 278).

The ankle is a hinge-joint, in which the articular surfaces of the lower end and internal malleolus of the tibia and of the external malleolus of the fibula form a mortice, into which the upper and lateral facets of the astragalus fit as a tenon. The transverse ligament helps to complete the tibio-fibular socket behind.

The *capsule*, strengthened and protected by the strong tendons passing over it, is divided, for description, into the following ligaments:

The *internal lateral* or *deltoid ligament* is a strong, flat, triangular band which radiates from the lower and ventral borders of the internal malleolus downward and backward to the rough inner surface of the astragalus, downward to the sustentaculum tali of the os calcis, and downward and forward to the scaphoid and the margin of the inferior calcaneo-scaphoid ligament. A so-called *deep portion* descends from the notch on the lower border of the malleolus to the depression on the inner surface of the astragalus.

The *external lateral ligament* presents three separate diverging bands: 1. The *anterior fasciculus*, short and ribbon-like, passes from the ventral border of the external malleolus obliquely forward to the astragalus, in front of its external lateral facet. 2. The *middle fasciculus*, strong and round, descends slightly backward from the tip and the fore part of the outer surface of the external malleolus to the middle of the outer surface of the os calcis. 3. The *posterior fasciculus* is the strongest, and passes from the dorsal border and the fossa on the inner side of the external malleolus almost horizontally inward to the outer surface of the astragalus, behind the facet, and to its external tubercle.

The *anterior ligament* is a thin, loose membrane in front of the joint between the lateral ligaments. It is attached above to the ventral margin of the lower end of the tibia, above a slight transverse groove, and below to the rough upper aspect of the head of the astragalus. A mass of fat beneath it rests in the groove of the neck of the astragalus.

The *posterior ligament* is very thin and weak, and consists of scattered oblique fibres between the dorsal margins of the articular surfaces of the tibia and the astragalus. The flexor longus hallucis tendon serves largely as a posterior ligament.

The *synovial membrane* is very loose on the anterior and posterior ligaments, forming folds between the tibia and the astragalus. It forms a short *cul-de-sac* between the tibia and fibula, in addition to lining the ligaments of the ankle.

Nerves.—Branches from the anterior and posterior tibial and the internal saphenous supply the joint.

The *movements* of the ankle are flexion and extension through a range of less than 90°. Flexion or dorsal flexion, in which the dorsum of the foot and toes approaches the leg, is limited by the posterior ligament, the posterior parts of the lateral ligaments, and by the contact of the ventral margin of the lower end of the tibia with the neck of the astragalus. In extreme flexion the fibula is slightly raised and spread somewhat from the tibia, to accommodate the wide fore part of the upper articular surface of the astragalus. Extension or plantar flexion, in which the toes are brought nearly into line with the leg, is limited by bony contact behind and by the tension of the anterior ligament and the anterior parts of the lateral ligaments. Extreme extension is accompanied by some adduction and slight supination of the foot, which probably occurs in the tarsal joints; for, although in this position the narrow dorsal part of the astragalus facet is less tightly held in the wide fore part of the tibio-fibular mortice, yet probably no lateral motion normally occurs except from external force. In the erect posture the line of gravity falls a little in front of the axis of the ankle, which is directed from within outward and backward, and therefore tends to flex it. Owing to the oblique axis of the ankle the leg moves forward and outward in flexion of the joint, but this outward movement of the legs cannot occur in the erect position, in which the legs are nearly parallel and cannot diverge from one another. Hence flexion is limited and the obliquity of the axis helps to secure stability in the erect attitude, which is otherwise dependent on muscular action. The lateral ligaments are often partly ruptured in sprains of the ankle and in "Pott's fracture."

5. The Tarsal Joints (Figs. 276–279).

The **Articulations of the Astragalus** consist of (1) a *posterior* and *external astragalo-calcaneal joint,* and (2) an *anterior* and *internal calcaneo-astragalo-scaphoid joint,* the fore part of which, or the astragalo-scaphoid portion, is partly supported and encapsulated by the two calcaneo-scaphoid ligaments uniting the os calcis and the scaphoid bone.

(1) In the *posterior astragalo-calcaneal joint* the dorsal pair of facets between these two bones are held together by a *capsule,* split up into several distinct slips as follows: An *internal astragalo-calcaneal band* passes from the internal tubercle of the astragalus, on the inner side of the groove for the flexor longus hallucis tendon downward and forward to the back of the sustentaculum tali. The *posterior astragalo-calcaneal ligament,* attached above to the external tubercle of the astragalus, spreads out onto the adjacent upper and inner surfaces of the os calcis. An *external ligament* connects the two bones beneath and in front of the middle slip of the external lateral ligament of the ankle, with which its fibres are parallel. The *interosseous ligament* is a strong band of fibres passing vertically between the grooves of the astragalus and os calcis, which together form the *sinus pedis.* It separates the two articulations between the astragalus and the os calcis, and consists of imperfectly separate layers, one of which serves as the anterior ligament of the posterior joint, and the other as the posterior ligament

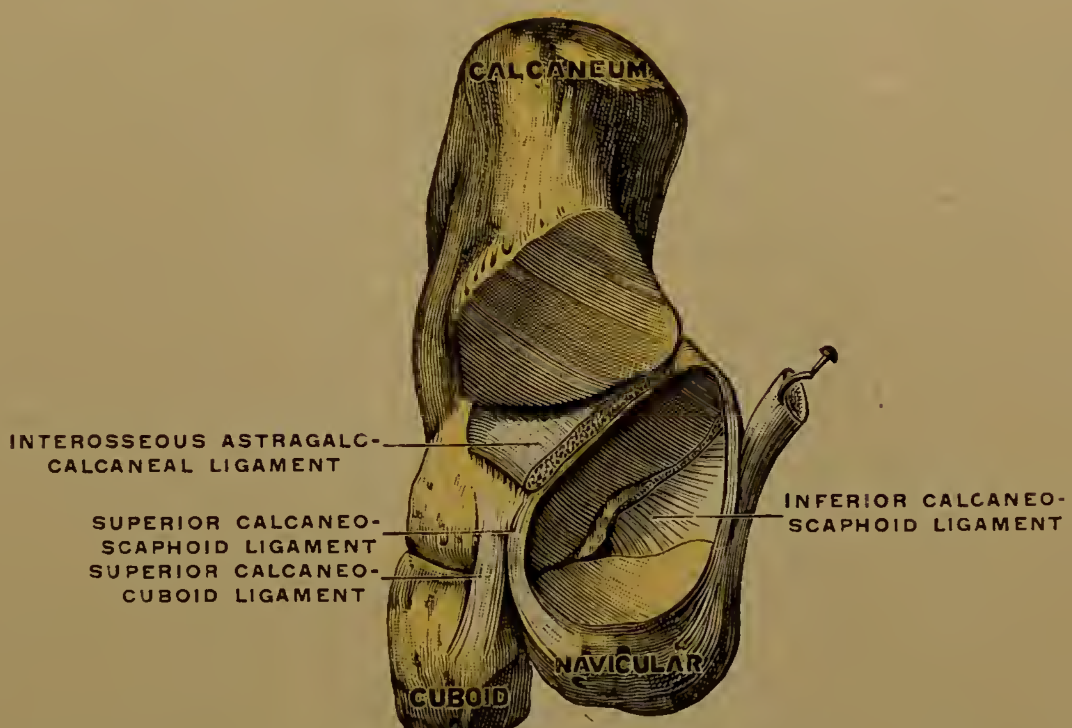

FIG. 278.—Medio-tarsal joint, viewed from above, the astragalus having been removed. (Testut.)

of the anterior joint. Furthermore, those parts of the lateral ligaments of the ankle which reach the os calcis help to unite it with the astragalus.

(2) The *calcaneo-astragalo-scaphoid joint* is between the anterior facet on the upper surface of the os calcis and the facets on the lower surface of the head and neck of the astragalus, and between the head of the astragalus and the scaphoid. The bones are held together by the following ligaments, in addition to the interosseous ligament, which limits the joint postero-externally.

Calcaneo-scaphoid Ligaments.—The *inferior* or *internal ligament* is broad, thick, and partly fibro-cartilaginous. It firmly unites the front and inner edges of the sustentaculum tali with the inferior surface of the scaphoid and its inner surface behind the tubercle. The upper surface of the ligament is smooth and articular, and completes the socket for the head of the astragalus below and internally. The upper part of its under surface presents a smooth facet for the tendon of the tibialis posterior, which aids in supporting the head of the astragalus. It is blended internally with the internal lateral ligament of the ankle, and externally and above with the *external* or *superior calcaneo-scaphoid ligament.* The strong

fibres of the latter ligament pass obliquely forward and inward from the fore part of the upper surface of the os calcis, external to its anterior upper facet, to the outer surface of the scaphoid. It limits both the anterior astragalo-calcaneal and the astragalo-scaphoid joints externally. The capsule of the astragalo-scaphoid joint is completed superiorly by the *astragalo-scaphoid ligament*, a broad, thin, membranous band, which converges from the upper surface of the head of the astragalus to the upper surface of the scaphoid.

The *synovial membrane* of the posterior astragalo-calcaneal and that of the calcaneo-astragalo-scaphoid joints are distinct, and separated from one another by the interosseous ligament.

The **Calcaneo-cuboid Articulation**, between the contiguous facets of the os calcis and the cuboid, forms, with that between the astragalus and scaphoid, the *medio-tarsal, transverse tarsal,* or *Chopart's joint.* The surfaces are held together by the following ligaments: The *inferior calcaneo-cuboid ligaments* consist of two portions, known as *plantar ligaments.* The superficial part, or *long plantar ligament,* arises from the under surface of the os calcis between the posterior and anterior tubercles, and extends forward to the oblique ridge on the under surface of the cuboid. From this ridge some fibres continue forward, bridging over and converting into a canal the groove for the peroneus longus tendon, and are attached to the bases of the outer four metatarsal bones. The deep portion, or *short plantar ligament,* attached to the under surface of the os calcis, to and in front of the anterior tubercle, extends forward and inward to the depression on the under surface of the cuboid behind the oblique ridge. The *superior calcaneo-cuboid ligament* connects the adjacent parts of the upper surfaces of the two bones, blending externally with the outer part of the short plantar ligament, and internally with the *internal* or *interosseous calcaneo-cuboid ligament.* This strong band connects the inner surfaces of the two bones near their articular margins, lying deeply in the hollow between the os calcis and astragalus, where it is closely connected with the external calcaneo-scaphoid ligament.

The *synovial membrane* is separate from that of the other tarsal joints.

Movements.—The movements of the fore part of the foot on the hind part take place at the medio-tarsal joint. The movements at the calcaneo-astragaloid joints are inversion and eversion (turning of the sole inward and outward respectively), and adduction and abduction (the movement of the front of the foot to and from the median line respectively). Both of these forms of movement occur also in the medio-tarsal joint, and besides them there is here quite free flexion and extension around an oblique axis, extending from within outward and somewhat backward and downward. Flexion is simultaneous with extension at the ankle, and extension, which is more limited, is simultaneous with flexion at the ankle. Thus, the variety and range of motion of the foot are increased beyond the limited flexion and extension allowed in the ankle. The astragalo-scaphoid joint is of the ball-and-socket variety, but, owing to the connection of the scaphoid and cuboid bones, its motions are restricted by the concavo-convex calcaneo-cuboid joint. In the medio-tarsal joint adduction and inversion are combined with flexion of the foot and abduction, and eversion with extension of the foot, the latter motion being limited by the plantar ligaments. The calcaneo-scaphoid ligaments also limit motion here. At the medio-tarsal and astragalo-calcaneal joints increase of the arch, combined with adduction and inversion, or decrease of the arch with abduction and eversion, may occur, leading respectively to club- or flat-foot, when for any reason these positions are exaggerated and permanent.

In the Cubo-scaphoid Joint the cuboid and scaphoid are united by—(1) a *dorsal ligament,* passing obliquely forward and outward from the scaphoid to the cuboid; (2) a *plantar ligament,* similarly disposed on the plantar surface; and (3) a strong *interosseous ligament,* connecting their contiguous surfaces, which, where they touch, present small articular facets, whose connecting ligaments are lined by an extension of the scapho-cuneiform *synovial membrane.*

The Scapho-cuneiform Articulation.—The scaphoid is united in one continuous joint to the three cuneiform bones in front of it by (1) strong *dorsal ligaments* from the upper surface of the scaphoid to that of each of the three cuneiform bones; and by (2) *plantar ligaments* similarly disposed beneath and continuous with the fibres of the tibialis posterior tendon. The latter tendon, by passing outward as well as forward, strengthens the transverse arch of the foot. The dorsal and plantar ligaments are continuous on the inner aspect of the internal cuneiform bone.

The Cubo-cuneiform Articulation.—Transverse fibres unite the dorsal, plantar, and contiguous surfaces of the cuboid and external cuneiform bones, forming the *dorsal, plantar,* and *interosseous ligaments.*

Intercuneiform Articulations.—The three cuneiform bones are similarly connected by transverse *dorsal* and strong *interosseous ligaments.* On the plantar surface there is a strong band passing outward and forward from the inner to the middle cuneiform bone, but the *tibialis posterior tendon* takes the place of the other plantar ligaments.

Synovial Membrane.—A single synovial cavity is common to the scapho-cuneiform and the intercuneiform joints, and usually to the cubo-cuneiform joint, though the latter may have a separate synovial cavity. The synovial cavity between the cuneiform bones usually extends forward between the internal and middle cuneiform, to become continuous with that of the tarso-metatarsal joints between the middle and external cuneiforms and the second and third metatarsals.

The *movements* in the above arthrodial joints, between the tarsal bones in front of the medio-tarsal joint, are limited to a slight gliding, due to the weight of the body rather than to muscular action, whereby the transverse arch of the foot is either flattened or deepened, thus increasing the elasticity and pliancy of the tarsus.

6. Tarso-metatarsal and Intermetatarsal Articulations.

Tarso-metatarsal Articulations.—The front surfaces of the three cuneiform bones and of the cuboid articulate with the proximal facets of the five metatarsal bones along a line (Hey's line) made irregular by the forward projection of the internal and external cuneiform bones. The first, second, and third metatarsals articulate with the internal, middle, and external cuneiform bones respectively, the fourth and fifth with the cuboid. The second metatarsal is wedged in between the internal and external cuneiforms and articulates with them laterally and with the middle cuneiform proximally. In addition, the fourth metatarsal bone usually articulates with the external cuneiform laterally. The surfaces are held together by dorsal, plantar, and interosseous ligaments. The *dorsal ligaments* are flat, thin bands which pass forward from the tarsal to the metatarsal bones. The first metatarsal bone receives one from the internal cuneiform; the second, one from each cuneiform; the third, one from the external cuneiform; the fourth, one from the external cuneiform and one from the cuboid; the fifth, one from the cuboid. The *plantar ligaments* are more irregular, and are strengthened by the expansions of the tibialis posterior and peroneus longus tendons and the long plantar ligament. The internal cuneiform is connected with the first metatarsal bone by a strong plantar band, and by another plantar band with the second and third metatarsal bones. Other slender plantar bands connect the metatarsal with their corresponding tarsal bones.

The *interosseous ligaments,* three in number, divide the synovial cavities of the tarso-metatarsal and intermetatarsal joints into three distinct parts, and offer resistance to disarticulation at the former joint: (1) A strong interosseous ligament passes from the outer surface of the internal cuneiform to the contiguous non-articular portion of the inner surface of the second metatarsal, and shuts off the synovial cavity of the first tarso-metatarsal joint from that of the second and third. The latter also extends between the bases of the second and third and between those of the third and fourth metatarsal bones, and is continuous with

that of the scapho-cuneiform joints, etc. (2) Another interosseous ligament separates the last-described synovial cavity from that between the fourth and fifth metatarsals and the cuboid, by passing from the antero-external edge of the external cuneiform to the inner surface of the fourth metatarsal behind its internal lateral facet, and to the opposed non-articular surfaces of the third and fourth metatarsal bones below their articular facets. This synovial cavity also extends forward between the fourth and fifth metatarsal bones. (3) A slender interosseous ligament often passes from the inner and front edge of the external cuneiform to the outer side of the second metatarsal bone.

Intermetatarsal Articulations.—*Proximal.*—The four outer bones articulate with one another laterally, and are firmly bound together by short transverse *dorsal, plantar,* and *interosseous ligaments.* The *interosseous ligaments* connect the rough parts of the lateral surfaces in front of the articular facets, and are very strong. The *dorsal ligament* between the internal cuneiform and the second metatarsal takes the place of one between the first and second metatarsal bones, between which there is often a bursa corresponding to an articular facet on the first metatarsal only. *Distal.*—The digital extremities are loosely connected on their plantar aspect by four transverse bands blending with the plantar sesamoid plates. These form the *transverse metatarsal ligament,* which differs from the similar structure in the hand in having a band between the first and second metatarsal bones.

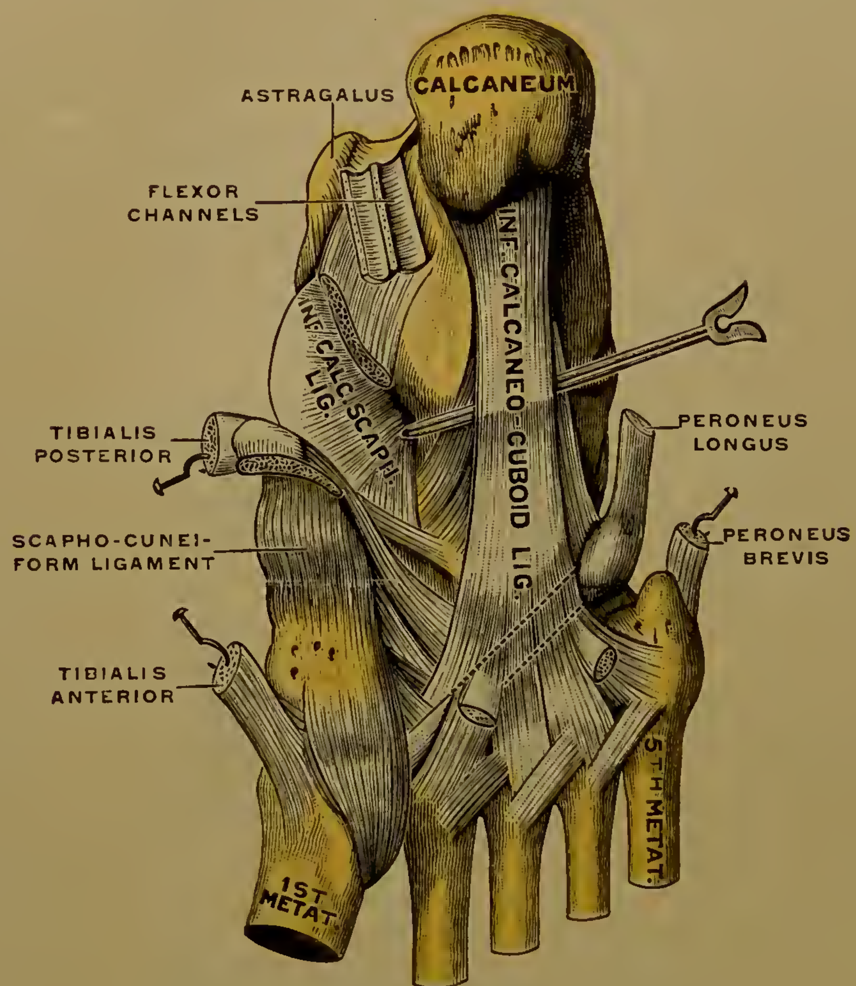

FIG. 279.—The plantar ligaments. (Testut.)

Movements.—In the tarso-metatarsal joints there are slight flexion and extension, combined in the first, fourth, and fifth joints with ab- and adduction, which are most free in the fifth joint. In the tarso-metatarsal and intermetatarsal joints there are also gliding movements, whereby the arch is altered and the foot adapted to the ground and made more elastic and flexible.

7. Metatarso-phalangeal and Interphalangeal Articulations.

The rounded heads of the metatarsal bones and the concave bases of the first phalanges form articulations similar to the corresponding joints of the hand. They are connected by *lateral ligaments* and a thick fibrous *plantar sesamoid plate.*

The latter is ossified laterally in the great toe-joint into two *sesamoid bones*, which give attachment to the flexor brevis tendons and bound a groove for the long flexor tendon.

The **phalanges** articulate with one another in the same manner as in the hand, and with the same ligaments (*i. e.*, lateral and an inferior or glenoid ligament). The second and third phalanges, however, are often ossified together in the foot. The dorsal ligaments of the above joints are principally formed by the extensor tendons. Each joint has a separate synovial membrane.

The *movements* also are similar to those in the hand, except that at the metatarso-phalangeal joints extension is more free than in the hand; lateral motions (adduction and abduction) are less free, and take place to and from the second toe as a centre; and the movements of the great toe are much more limited than those of the thumb.

Mechanism.—In walking the heel is the first part of the foot to touch the ground, and the weight of the body is transmitted to it through the posterior calcaneo-astragaloid joint, the foot being slightly adducted. As the other foot swings forward the outer border of the supporting foot is raised from the ground and the weight is transmitted to the inner toes; the foot becomes abducted, and leaves the ground by means of flexion of the great toe. In standing, the longitudinal arch is supported and the weight of the body borne by the plantar and calcaneo-navicular ligaments. The oblique direction of the expansion of the tibialis posterior and peroneus longus tendons, forward and outward and forward and inward respectively, help to support the longitudinal as well as the transverse arch of the foot. The latter is also supported by the transverse plantar and interosseous ligaments. The heads of the metatarsal bones, on which, and not on the toes, the foot rests in front, are somewhat spread out by the weight of the body, when the foot is raised on the toes.

THE MUSCLES.

By F. H. GERRISH.

A muscle is an organ whose essential part is a mass of striated muscular tissue, prolonged at its opposite ends or margins by cords, bands, or sheets of white fibrous tissue, which are fastened to other structures, usually bones. The muscular tissue is contractile, and is the active portion of the organ; the fibrous is strong and flexible, but is only passive. The contractile portion is called the *muscle proper*, the *belly*, or the *body of the muscle*; the fibrous extensions are called *tendons* (sinews), and sometimes, when greatly expanded, *aponeuroses*. The muscle proper may be compared to an engine, in which force is generated; its tendons to the ropes by which the power is applied to distant objects.

The relation of the tendons to the body of the muscle varies greatly in different muscles, both as regards their proportion and their arrangement. The belly may have tendinous structure only at its extremities, or one or both of the tendons may start far back upon the surface of the contractile mass, or a tendon may be in large part concealed in the midst of the muscular tissue. Several plates of tendon may be thus embedded, all connected with the terminal cord. When the tendons are found only at the ends of a muscle, the fibres of the two kinds of tissue are substantially in the same axis; but, when one of the other arrangements obtains, the muscular fibres are placed at an angle to the tendinous, as the barbs of a feather are related to the quill.

In a few muscles there is a *third tendon* midway of its contractile mass, which is thus divided into two, becoming *double-bellied*—in technical phrase, *digastric* or *biventral*. One or more narrow, fibrous interruptions, partial or complete, may occur in some long muscles, constituting *tendinous inscriptions*.

Bones in Tendons.—Small osseous masses, called *sesamoid* ("like sesame") *bones*, are sometimes developed in tendons at points where they play over joints and are exposed to great pressure. Some of these are constant, as the patella, which is a sesamoid bone in the great muscle which straightens the leg on the thigh.

Synovial Sheaths of Tendons.—Synovial membrane of the vaginal form is developed around many tendons which run in canals, as in the case of various digital muscles. *Bursal synovial membranes* are found at very many spots where tendons press upon one another or upon other organs, especially where they pass over prominences of bone. An *articular synovial membrane* may be prolonged beyond its joint, and furnish a lubricating sheath to the tendon of a neighboring muscle.

Attachments of Tendons.—A tendon may be long or short; it may resemble a cord, a ribbon, or a sheet. In the last case it is commonly called an aponeurosis—an undesirable, because etymologically misleading, name, but now firmly fixed by eminent sanction. Tendons are usually fastened to bones and cartilages, but may be attached to ligaments, skin, and other soft parts. The fibrous tissue of the tendon intermingles, and becomes continuous, with the periosteum of the bone, the perichondrium of the cartilage, or the deep layer of the skin, thus blending with a structure which is histologically identical with itself. When one con-

siders the intimacy of relation between periosteum and bone, he is not surprised at the infrequency of the separation of a tendon from its osseous attachment.

Proportionate Increase of Tendons with Age.—The tendinous portion of a muscle increases with years, and on this account the muscles of an adult are stiffer than those of a child, and the range of joint-movement is diminished. A child's extended lower limb may be kept at a right angle with his trunk for a long time without causing him any discomfort; but the same procedure cannot be practised upon an adult without producing great suffering and perhaps injury. The difference is due to the normal muscular extensibility in the infant on the one hand, and the equally normal tendinous inextensibility in the adult on the other.

Origin and Insertion of Muscles.—A muscle is attached to two objects, and by its contraction lessens the distance between them. The part which is fastened to the more fixed of these objects is called the *origin*, the other the *insertion*. The origin is generally, especially in the limbs, proximal, the insertion distal. But the terms are entirely physiological and largely conventional, for in case of many muscles there is room for difference of opinion as to which portion is the more entitled to be called origin—the action being as frequently from one end as from the other.

Fasciæ.—The muscles in a region are maintained in close relations with each other by strong sheets of white fibrous tissue, which are wrapped firmly around them and often send shelves between them. These fibrous expansions are called *fasciæ* ("bandages"), and also *aponeuroses of investment*. They will be described in detail after the muscles have been considered. It will suffice here to remark that it is common for muscles to have extensive attachments, either of origin or insertion, to the fasciæ which cover and separate them from their immediate neighbors.

Ligamentous Action of Muscles.—The muscles perform a valuable service in keeping the cartilaginous surfaces of the movable joints in contact. The ligaments proper are in many cases utterly inadequate for this work, as witness the joint between the shoulder and arm: remove the muscles and the humerus drops away from the glenoid fossa. But the muscles, which normally are never fully relaxed, keep up a tireless pressure, and, excepting violent accidents, never allow a separation to occur. This unvarying normal tension of muscular tissue is an obstacle to the reduction of fractures and dislocations; for as soon as a bone is thrown out of its position, or a breach in the continuity of its substance occurs, the neighboring muscles, in demonstration of their being constantly somewhat tense, pull the luxated bone still further out of place, or cause the fragments to overlap each other. The muscular force is often so great as to require much strength, or anæsthesia, or both, to overcome it.

The Mechanics of Muscular Attachments.—The points of attachment of most muscles are such as to place these organs at a great mechanical disadvantage. This is very evident in a large part of the muscles of the limbs. Take, for example, a muscle which bends the forearm upon the arm. It is attached to the lower half of the front of the humerus, crosses the elbow-joint, and just below this is attached to the ulna (Fig. 280). The loss of power involved here is illustrated in a homely way by comparing the effort required to close a door by pulling it toward one, when it is grasped at a point near the hinges, with that which suffices when it is seized near its free edge, where the knob is usually placed. Manifestly the latter method is vastly easier. If the same plan were adopted in the flexion of the forearm, the muscle would be attached high on the humerus and low on the ulna (Fig. 281). But, although this would be advantageous as regards the expenditure of force, it would be strikingly otherwise in directions of quite as much importance. In the first place, the contraction of muscular tissue shortens it to one-half its length and no more, on which account the forearm could be bent upon the arm only to B, instead of to a much higher point, C, which is normally reached. In the second place, there would be a loss of rapidity

of movement of the lower end of the limb about proportionate to the gain of power; for the nearer to the hinge the force is applied, the more rapid will be the movement of the long arm of the lever. Then, the occupation by the muscle of each successive portion of the great triangular space included by it and the two bones when in flexion would be an intolerable interference with the usefulness of the limb, practically reducing the carrying power of the front of the forearm to

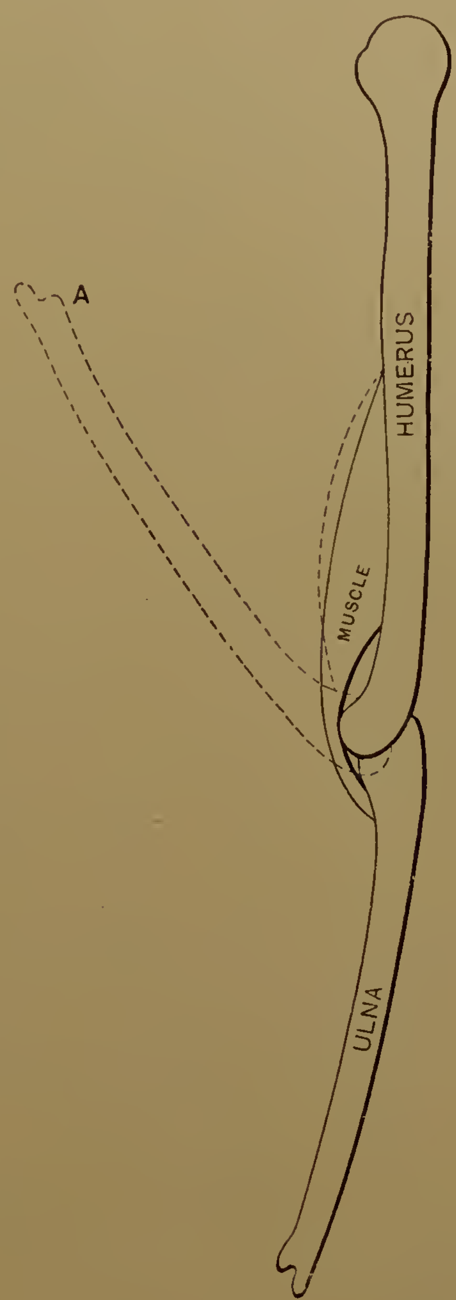

Fig. 280.—Diagram showing the mechanical disadvantage of the points of attachment of many muscles. (F. H. G.)

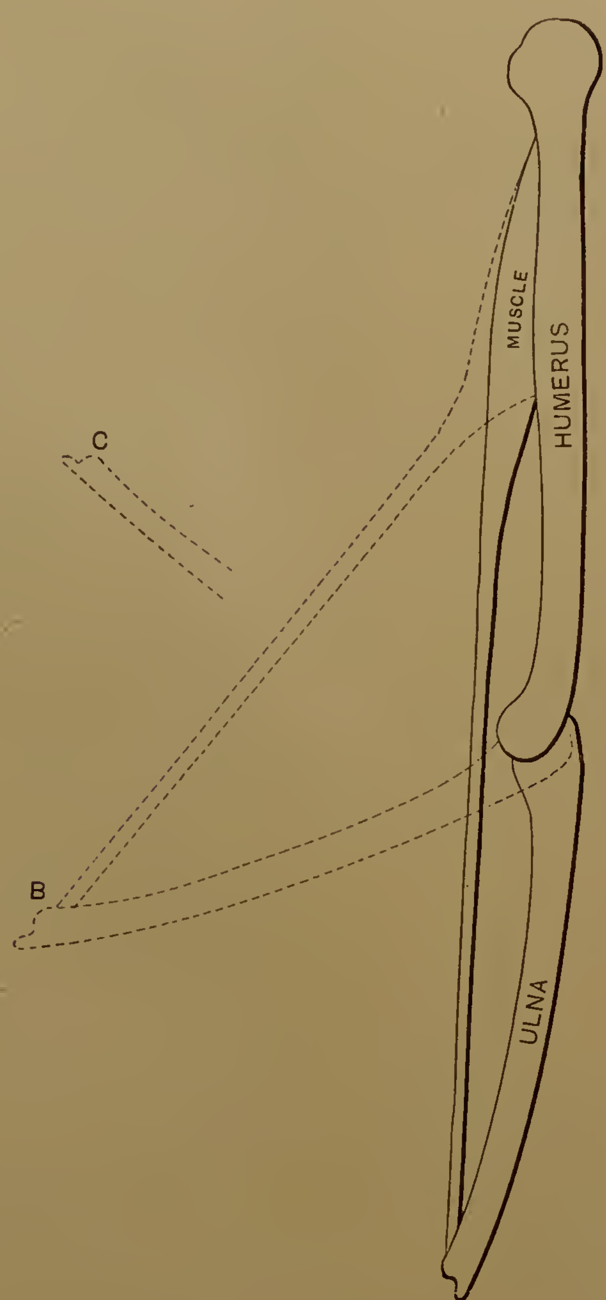

Fig. 281.—Diagram showing the effect of attaching a limb-muscle at points of the greatest mechanical advantage. (F. H. G.)

nothing. There would also be a loss of a great deal of the important ligamentous work of the muscles by their removal from close contact with the joints during their most pronounced activity. Thus it will be seen that the condition which exists, while extremely costly in the matter of muscular expenditure, is attended with advantages which are more than compensatory.

Change in Direction of Muscular Force.—Tendons are often made to pass around prominences and through loops, the force originating in the muscle thus experiencing a change of direction, as in the case of a rope which runs from an engine through a pulley to an object which is to be hoisted. The contractile force of such a muscle is applied in line with the portion of its tendon lying between the last angle which it makes and the point of its attachment to the object to be moved. On account of the lubrication of the tendon by synovia, which is always present in such cases, no appreciable loss of power is experienced by the change of direction.

Primary, Secondary, Direct, and Reversed Actions.—A muscle which crosses

only one joint has but two possibilities of action: one, which may be called its *direct action*, is from a fixed origin to a movable insertion; the other, its *reversed action*, is from a fixed insertion to a movable origin. But many muscles cross two or more joints, and by so much is the number of their movements augmented. For instance, the superficial flexor of the fingers primarily and directly flexes the second phalanges upon the first phalanges (Fig. 282, A); but, when this movement is completed or is prevented, continuance of the contraction causes flexion of the first phalanges upon the metacarpal bones, and this may be called the *direct secondary action* (Fig. 282 B). When this movement is accomplished or arrested, still further contraction produces flexion of the whole hand upon the forearm—the *direct tertiary action* (Fig. 282, C); and, finally, by persistence in the performance, the forearm is flexed slightly upon the arm—the *direct quaternary action* (Fig. 282, D). The reversed actions in these various stages are too obvious to require description.

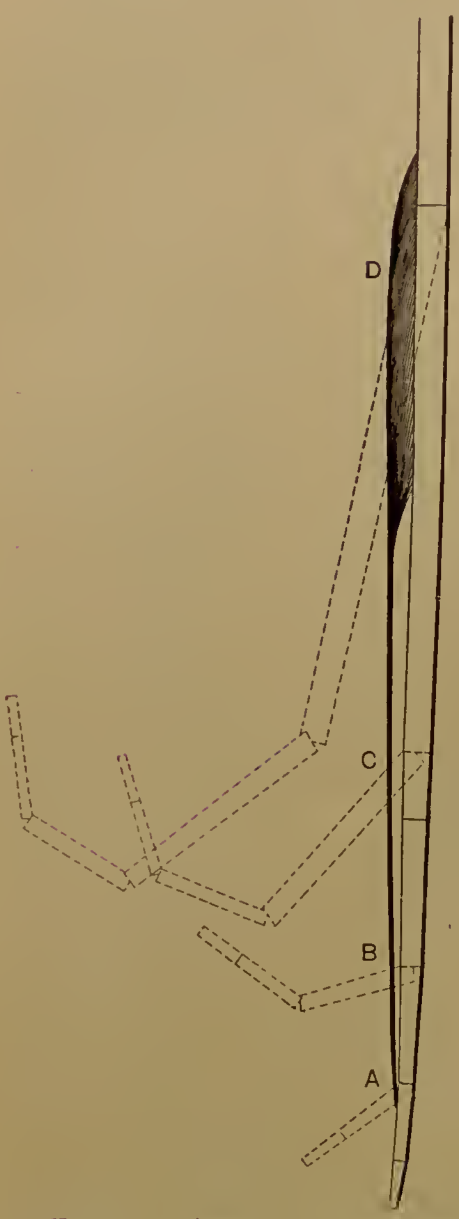

FIG. 282.—Diagram showing the primary, secondary, tertiary, etc. actions of a muscle. (F. H. G.)

The segment of a limb on which a muscle acts carries with it, of course, all of the parts distal to it; and the movement effected by the contraction of the muscles is more manifest upon those parts than upon the segment bearing them, since they describe larger arcs. This is particularly noticeable in the pronation and supination of the radius. The change in the relation of the lateral parts of the forearm is far less apparent than the alteration in the attitude of the hand, which passively accompanies the radius.

The Blending of Muscles.—Muscles are often associated in groups so intimately that, either at origin or insertion, there is an actual blending of substance. Myologists have not agreed upon an absolute rule for the settlement of the question of division or unification in these cases, some describing as two or three distinct muscles what others regard as a compound one. There is much in this connection which is conventional and arbitrary, and, consequently, perplexing.

The Muscles in Pairs.—Almost all of the skeletal muscles are arranged in pairs, and thus a description of one on either side will answer for its mate on the opposite side. A few are single and located about the median line, and in these there is generally a bilateral symmetry.

The Size of Muscles varies from a fraction of an inch to many inches. In form they are extremely diverse, and only in a small proportion is their resemblance to familiar objects sufficiently striking to justify the application of names intended to be descriptive of their shape.

The Nomenclature of Muscles.

Latinity of Names.—The muscles are almost always called by their Latin names. A few have become Anglicized, commonly by the omission of the termination (as *deltoid* instead of *deltoideus*); but the attempts which have been made to displace the Latin appellations by substituting English translations of them have always failed. The student, however, should learn the exact meaning of every name, as this knowledge cannot fail to be of great assistance to him. For example, almost one-half of the names of the muscles moving the several

segments of the upper limb, are descriptive of the action of these muscles, and nearly two-thirds of these convey some additional information—of form, situation, or size. The majority of the names of the other half of this group indicate position, and the residue call attention to some characteristic of shape or resemblance. From this it will be seen that the names are not arbitrary, but are designed to be descriptive, and, consequently, are helpful in the first learning and in the permanent retention of the facts.

The Latin word *musculus* ("muscle") is always implied in the name of a muscle, and the part which is expressed is either an adjective or a noun in apposition, with or without limiting words.

Reasons for the Names of Muscles.—Muscles are named from various considerations, and occasionally more than one of these is appealed to in the selection of a name. It is noticeable that the names of individuals are not used in the nomenclature of muscles, as they are in almost every other branch of anatomy.

The following are the principal derivations of the names of muscles: 1, *action* or supposed action, as levator scapulæ, "the lifter of the shoulder-blade," supinator, "the muscle producing supination"—turning the part onto its back; 2, *form*, as gracilis, "the slender muscle," serratus, "the saw-toothed muscle;" 3, the *form of two muscles* symmetrically located on opposite sides of the body, as trapezius, "the table-like muscle," though each trapezius is not trapezoid but triangular; 4, *resemblance to a natural object*, as lumbricalis, "the earthworm muscle," soleus, "the sole-fish muscle;" 5, *situation*, as frontalis, "the forehead muscle," subclavius, "the muscle under the collar-bone;" 6, *attachments*, as coraco-brachialis, "the muscle connecting the coracoid process and the arm," brachio-radialis, "the muscle connecting the arm and the radius;" 7, *size*, either absolute, as vastus, "the great muscle," or comparative, as latissimus, "the broadest muscle;" 8, *division*, as quadriceps, "the four-headed muscle," multifidus, "the muscle of many clefts;" 9, *paired condition*, as gemellus, "the twin muscle;" 10, *supposed singleness*, as azygos uvulæ, "the uvula muscle not yoked to a mate;" 11, *involvement of structure*, as complexus, "the complicated muscle;" 12, *direction of fibres*, as rectus, "the straight muscle," transversalis, "the transverse muscle;" 13, *relative proportion of contractile and non-contractile tissues*, as semimembranosus, "the half-membrane muscle," semitendinosus, "the half-tendon muscle;" 14, existence of a *tendon midway between two contractile portions*, as digastric and biventer, "the muscles with two bellies;" 15, *occupation* in which the muscle is thought to be useful, as sartorius, "the tailor's muscle," buccinator, "the trumpeter's muscle;" 16, *expression produced*, as risorius, "the laughing muscle;" 17, *the subordinate character of the work done*, as accessorius, "the assistant muscle."

Names of Movements Produced.—Most of the movements of the parts upon which muscles act have received specific names, some of which are applied also to the attitudes resulting from these movements. When one part is bent upon another, the movement is called *flexion* ("a bending"); when the part is straightened out, the action is *extension* ("a stretching"); and thus flexion and extension are antagonistic actions and attitudes. The moving of a part further away from the middle line (the median plane of the whole body being meant, unless otherwise specified) is *abduction* ("a drawing from"); the opposite movement, by which the part is restored to its former position, is *adduction* ("a drawing to"). The slight difference between these antipodal words should be noted—the one begins with *ab*, the Latin for "from," the other with *ad*, the Latin for "to." When a part is made to revolve upon its long axis, the movement is *rotation*, ("a revolving"); and when its lower extremity is caused to describe a circle, and the part itself thus traverses the periphery of a cone, the action is *circumduction* ("a drawing around"). The movement which turns a part onto its face is *pronation* ("a bending forward"), and the reverse is *supination* ("lying on the back").

The Order of Study.—The muscles will be considered in the following order:

The muscles of THE UPPER LIMB.

The muscles of THE LOWER LIMB.

The muscles of THE TRUNK.

(*a*) those of *the back*, including the dorsum of the neck.

(*b*) those of *the abdomen*.

(*c*) those of *the thorax*.

The muscles of THE NECK, at the front and sides.

The muscles of THE HEAD.

The muscles of the *tongue*, *pharynx*, and *soft palate* will be presented in connection with the organs of digestion; those of the *larynx* with the respiratory system; those of the *eye* and *ear* with special sense organs; and those of the *perineum* with the genitals.

Illustrative Pictures are provided so liberally in this chapter, and show certain details so clearly, that it is practicable to omit from the verbal descriptions many things which are usually given in them, and this, too, not only without diminution of clearness, but often with distinct advantage in this regard, since facts can usually be more quickly apprehended and more firmly held when presented by pictorial means, than when introduced into the mind through the medium of words. Thus, the form of a muscle, the most important relations of its contractile and tendinous portions, and its principal relations to neighboring muscles are generally shown so plainly in the drawings of dissections, that their description can safely and profitably be omitted from the text.

The Outline Drawings *of individual muscles show in each instance the location and proportionate size of the areas of osseous origin and insertion, and also the margins of the entire muscle from the selected point of view, thus suggesting its action. In cases where a surface of attachment or a part of the outline is not visible from the chosen point, the concealed portion is drawn in dots or broken line, and is represented as if the intervening skeletal structure were transparent.*

Minuteness of verbal description of muscular attachments, while morphologically interesting, is of little or no practical value to the physician and surgeon, and, consequently, is not attempted. The essential facts are presented in the text, and in most cases are abundantly illustrated in the outline drawings.

Connection with Neighboring Soft Parts.—*The attachments to superjacent fasciæ, intermuscular septa, and other soft parts will often be omitted from the text for the sake of brevity, especially when these are of insignificant extent, or have already been mentioned in connection with the group of muscles concerned. It may usually be assumed that a muscle has some attachment to the fibrous structures—investing sheets, partitions between it and its immediate neighbors, ligaments, etc.—with which it is in close contact.*

The Action assigned to a muscle is that effected by its contraction from a fixed origin to a movable insertion—the direct primary action—unless otherwise specified. The direct secondary and all reversed actions can be worked out correctly and easily by one who has learned the direct primary action and the anatomical reasons for it.

Classification of the Limb Muscles.—The classification of the muscles of the limbs which is here given is physiological, being based upon their primary and most characteristic action. Although this grouping is very different from that which is generally followed, it is believed to be more useful as an aid in learning the facts of greatest importance in myology, and in applying the knowledge thus gained in medical and surgical practice. Of course, it is not claimed that this classification is perfect—none which rests upon a physiological basis can be; but long employment of it has demonstrated its utility in attracting and holding the interest of the student, and this mainly because there is kept constantly in view the application of the facts which he is learning. After the muscles of a limb have been described, their classification on a regional basis will be presented.

THE MUSCLES OF THE UPPER LIMB.

Movements of the Upper Limb.

Each of the four primary segments of the upper limb is capable of a wide range of action.

Movements of the Shoulder.—In the chapter on the joints the scapula is shown to be somewhat movable upon the clavicle; but, in studying the principal action of the muscles, the movements of the claviculo-acromial joint may be ignored without serious departure from the fact, and the skeleton of the shoulder may be regarded as practically a single bone. This framework is pivoted upon the trunk at the sterno-clavicular articulation, and is proximally attached at other points by muscles only. The movements of the shoulder, therefore, centre on the upper end of the sternum, and are made upward, downward, forward, and backward, the terms used to designate them—elevation, depression, etc.—requiring no explanation.

Movements of the Arm.—The arm, being united to the shoulder by means of a ball-and-socket joint, can be moved in every direction which is consistent with the integrity of the articular structures and with the retention of the humeral head in the glenoid fossa. Its movement forward is *flexion*, backward is *extension*, outward is *abduction*, inward is *adduction*. When it is rolled on its own axis so that its front turns toward the trunk, the movement is *inward rotation*; when it revolves so as to turn its front away from the trunk, the action is *external rotation*. Its *circumduction* is *inward* when the front semicircle described by the lower end of the arm is made from the outside toward the mid-line, and the opposite movement is *outward circumduction*.

Movements of the Forearm.—The elbow-joint proper is a hinge, allowing motion between the forearm and arm only forward, which is *flexion*, and backward, which is *extension*. Between the two forearm bones, however, are movements which consist in the overlapping of the ulna by the radius, *pronation*, and the opposite action by which the parts are restored to their anatomical attitude, *supination*.

Movements of the Hand.—The articulation between the forearm and carpus permits motion of the hand forward, which is *flexion*, backward which is *extension*, sidewise toward the mid-line, *adduction*, and from this line, *abduction*. *Circumduction*, which is accomplished by a combination of these movements, is inward or outward, according to the rule given above. In these various movements of the whole hand some motion takes place in the joints between the carpal bones; but these are so slight as to be practically inappreciable, and require no further mention.

Movements of the Metacarpal Bones.—The *second*, *third*, and *fourth metacarpal bones* are so firmly joined to the carpus that but little motion is possible, even when their respective digits are most forcibly acted upon. The *fifth metacarpal bone* has an appreciable forward movement, which is *flexion*, a backward, which is *extension*, and slight lateral motions, *abduction* and *adduction*. The *first metacarpal* is so articulated at the wrist that its range is very great, and this freedom of action is more than a compensation for the deficiency of a phalanx in its digit.

Movements of the Common Digits.—Forward movement of the *fingers* and of each of their phalanges is *flexion*, and backward movement is *extension*. The lateral movements of the fingers are called *abduction* and *adduction*; but the median line of the body is not here taken as the plane from and to which the action is reckoned, a line drawn through the middle of the middle finger when it is in repose being substituted. There is practically no lateral motion at the interphalangeal joints.

Movements of the Thumb.—It is to be particularly noticed that the first metacarpal is so placed that the thumb is in advance of the plane of the other digits and its palmar aspect is about at a right angle with theirs. Consequently, a bending at the joints of the thumb toward its palmar aspect, which is *flexion* (as in the case of the other digits), causes it to cross the palm of the hand toward the hypothenar eminence. The restoring movement is *extension*. *Abduction* of

the thumb is in the direction of flexion of the fingers, and its *adduction* is in the direction of their extension. Its circumduction requires no especial description.

It will be observed that, from the shoulder-joint down, the *forward movements are flexions*, and the *backward movements are extensions*—the thumb offering the only exceptions. In the lower limb this rule does not apply.

Classification of the Muscles of the Upper Limb on the Basis of their Principal Action.

Moving the Shoulder.

Upward and backward.	*Downward and forward.*
Trapezius.	Serratus magnus.
Levator scapulæ.	Pectoralis minor.
Rhomboideus minor.	Subclavius.
Rhomboideus major.	

Moving the Arm.

Abductors.	*Adductors.*
	Pectoralis major. } *also flexors.*
Deltoideus.	Coraco-brachialis. } *also flexors.*
Supraspinatus.	Latissimus. } *also extensors.*
	Teres major. } *also extensors.*

Outward Rotators.	*Inward Rotator.*
Infraspinatus.	Subscapularis.
Teres minor.	

Moving the Whole Forearm.

Flexors.	*Extensors.*
Biceps flexor cubiti.	Triceps extensor cubiti.
Brachialis.	Anconeus.
Brachio-radialis.	

Moving the Outer Part of the Forearm.

Pronators.	*Supinator.*
Pronator teres.	Supinator.
Pronator quadratus.	

Moving the Whole Hand.

Flexors.	*Extensors.*
Flexor carpi radialis.	Extensor carpi radialis longus.
[Flexor] palmaris longus.	Extensor carpi radialis brevis.
Flexor carpi ulnaris.	Extensor carpi ulnaris.

Moving the Fingers and the Fifth Metacarpal Bone.

Flexors.	*Extensors.*
Flexor sublimis digitorum.	Extensor communis digitorum.
Flexor profundus digitorum.	Extensor minimi digiti.
*Flexor ossis metacarpi minimi digiti.	Extensor indicis.
*Flexor brevis minimi digiti.	
*Lumbricales.	

Abductors.	*Adductors.*
*Interossei dorsales.	*Interossei palmares.
*Abductor minimi digiti.	

Moving the Thumb and its Metacarpal Bone.

Flexors.	*Extensors.*
*Flexor ossis metacarpi pollicis.	Extensor ossis metacarpi pollicis.
*Flexor brevis pollicis.	Extensor brevis pollicis.
Flexor longus pollicis.	Extensor longus pollicis.

Abductor.	*Adductor.*
*Abductor pollicis.	*Adductor pollicis.

* Situated entirely in the hand.

MUSCLES MOVING THE SHOULDER.

Upward and backward.	*Downward and forward.*
Trapezius.	Serratus magnus.
Levator scapulæ.	Pectoralis minor.
Rhomboideus minor.	Subclavius.
Rhomboideus major.	

All of these muscles arise from the trunk, excepting one, which has its origin in the neck. All are inserted into the skeleton of the shoulder.

Trapezius (Figs. 283, 284).—So called from the resemblance which it with its mate bears to a four-sided table (Greek *trapeza,* "a table"). *Synonym,* cucullaris,

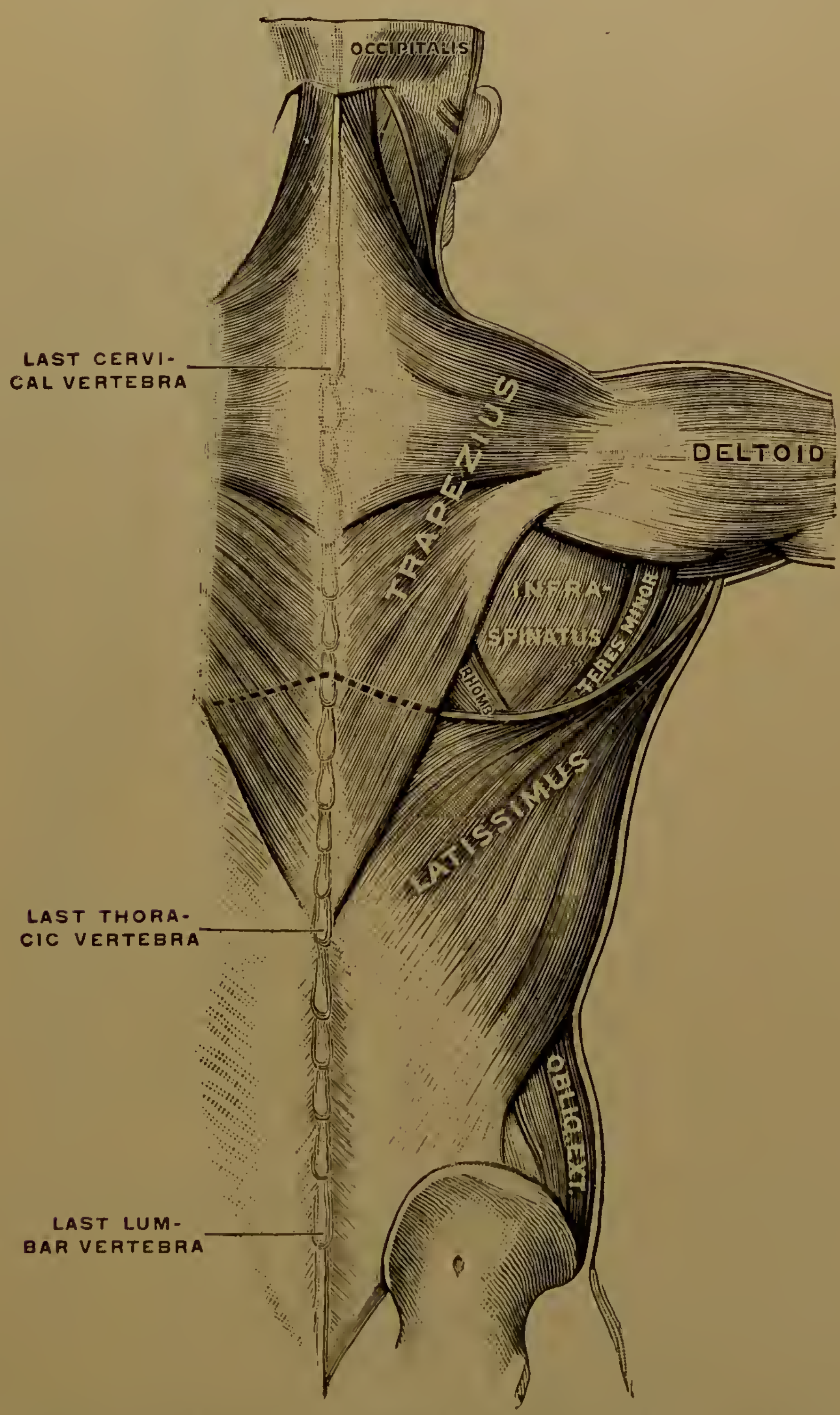

Fig. 283.—Muscles in the superficial layer of the back. (Testut.)

from the likeness of the pair to a monk's hood (Latin *cucullus*). *Situation,* superficial, on the dorsal aspect from the occiput to the base of the thorax, and lat-

erally to the peak of the shoulder; also, at the side of the neck, and the top and front of the shoulder. *Origin*, the inner third of the superior curved line and the protuberance of the occipital bone, the ligamentum nuchæ, the spines of the last cervical and all of the thoracic vertebræ, and their supraspinous ligament. *Direction* of fibres, convergent: the upper, down-, out-, and forward; the middle, outward; the lower, up- and outward. *Insertion*, the outer third of the hind border of the clavicle, the inner border of the acromion, the upper border of the scapular spine, the tubercle near its inner end. *Action*: the upper

FIG. 284.—Trapezius of right side: outline and attachment-areas. (F. H. G.)

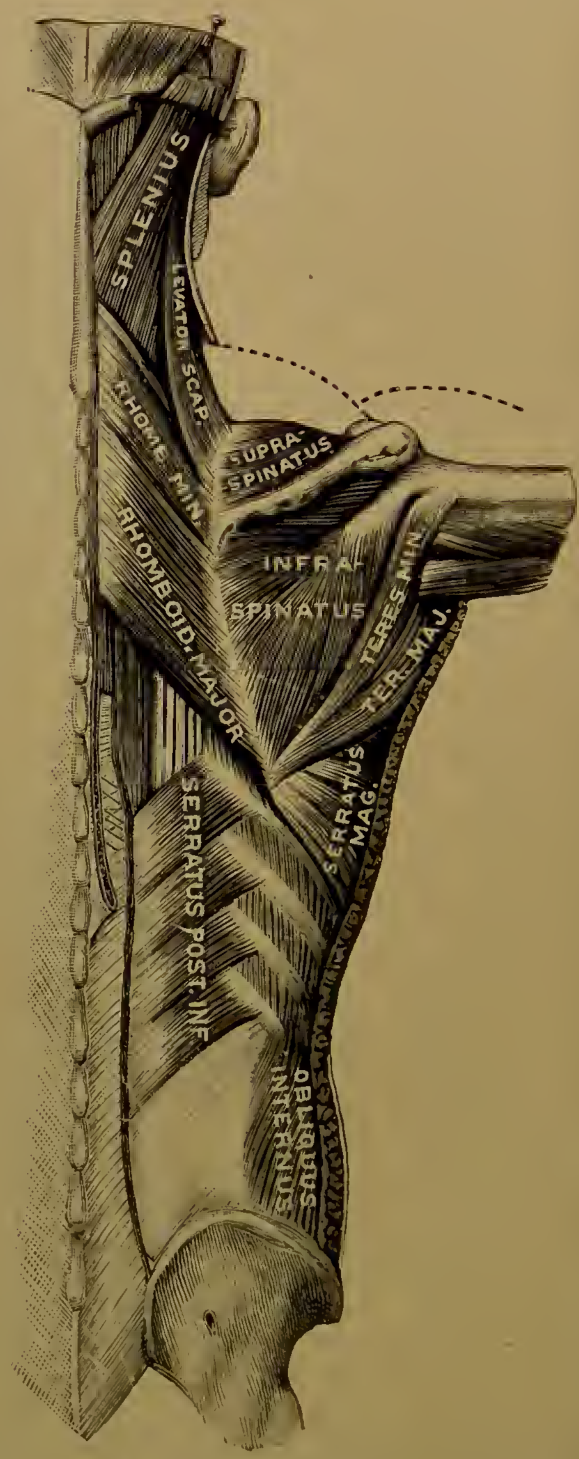

FIG. 285.—Muscles in the second layer of the back and on the dorsum of the shoulder. (Testut.)

part raises the shoulder, the middle draws the shoulder toward the spine, the lower pulls the scapula down- and inward, and tilts the acromion upward. All together lift the shoulder and rotate the lower angle of the scapula outward. *Nerves*, the spinal accessory, and the third and fourth cervical.

Levator Scapulæ (Figs. 285, 286).—"The lifter of the scapula." *Synonym*, levator anguli scapulæ, "the lifter of the angle of the scapula." *Situation*, on the side of the neck from the vertebræ to the upper scapular angle. *Origin*, the hind

tubercles of the transverse processes of the upper four or five cervical vertebræ. *Direction,* down-, out-, and backward. *Insertion,* the vertebral border of the scapula from the upper angle to the root of the spine. *Action*: it lifts the upper angle of the scapula and depresses the tip of the shoulder. *Nerves,* the third, fourth, and fifth cervical.

Rhomboideus Minor (Figs. 285, 287).—"The smaller rhomb-shaped muscle." *Situation,* in the back, between the spinal column and the scapula. *Origin,* the

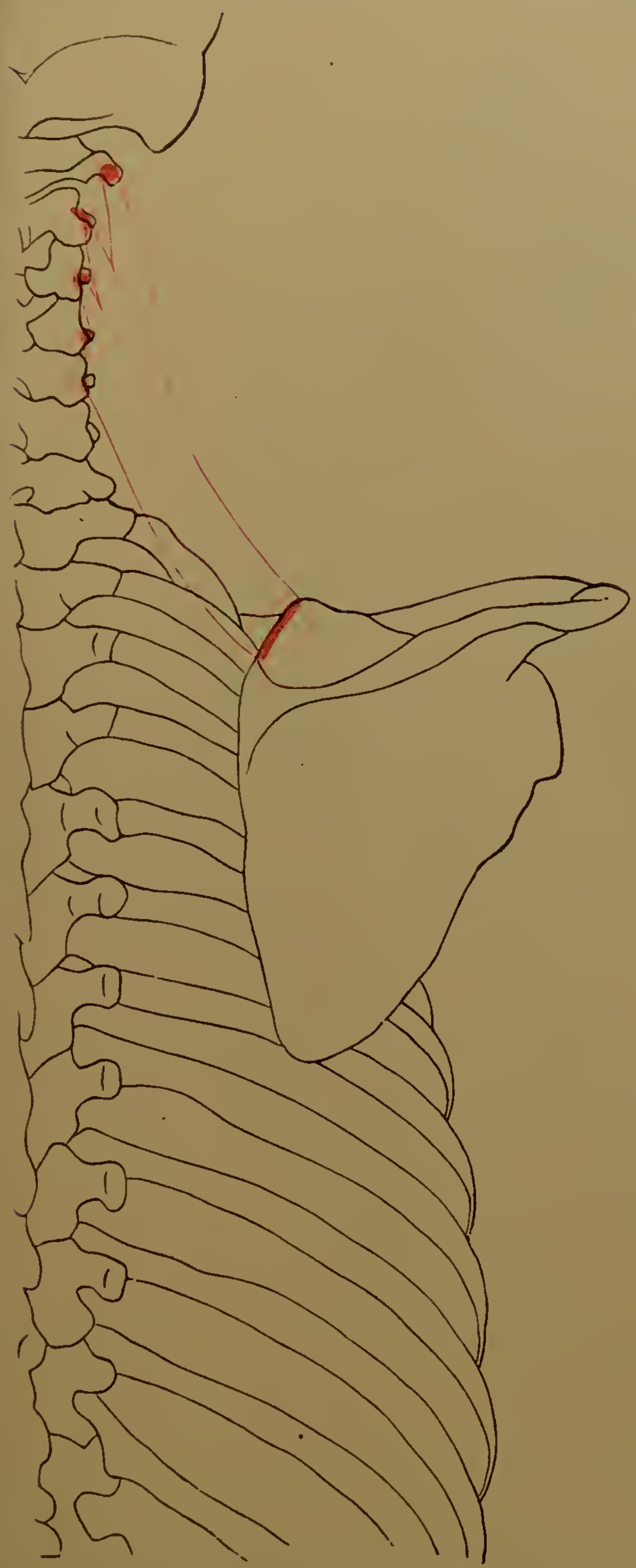

FIG. 286.—Levator scapulæ of right side, rear view: outline and attachment-areas. (F. H. G.)

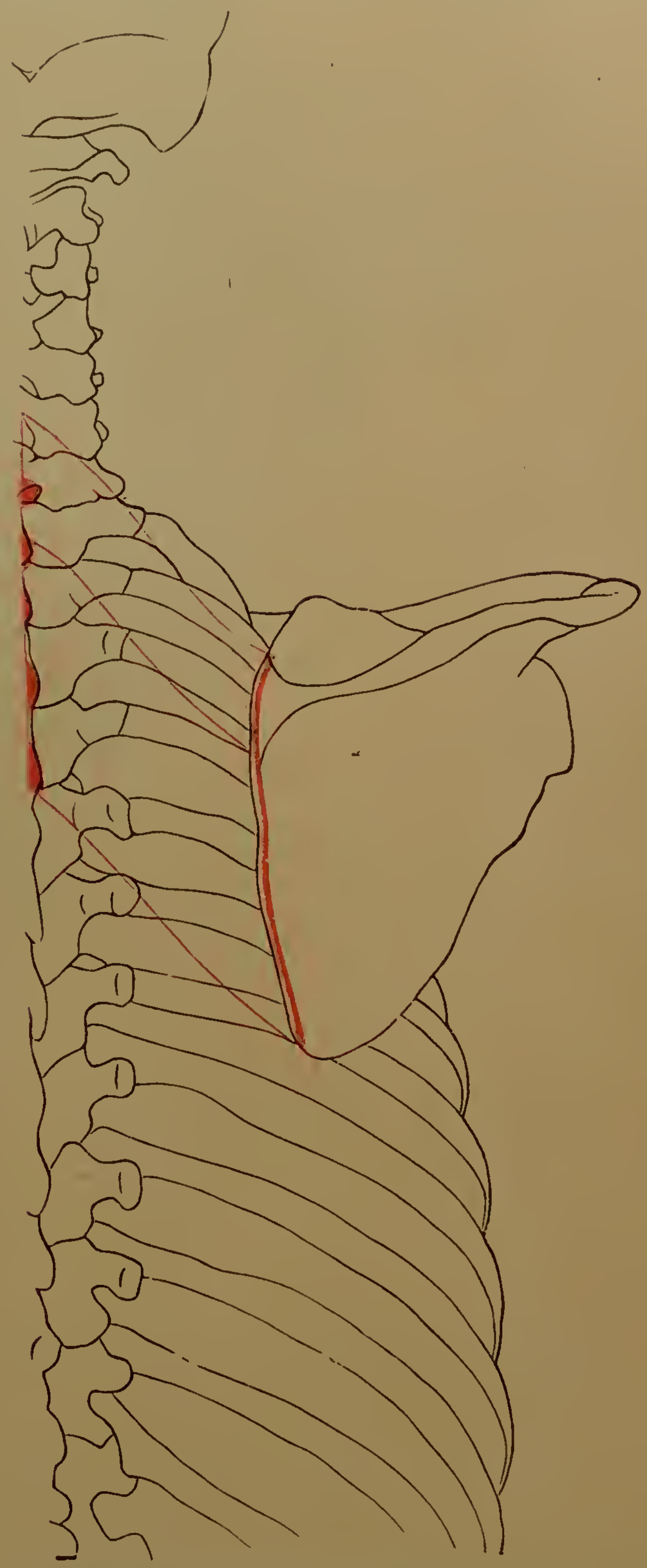

FIG. 287.—Rhomboideus minor and rhomboideus major of right side: outline and attachment-areas. (F. H. G.)

lower part of the nape ligament, the spines of the seventh cervical and first thoracic vertebræ. *Direction,* down- and outward. *Insertion,* the vertebral border of the scapula at the root of its spine. *Action*: it draws the scapula up- and inward, and depresses the tip of the shoulder by rotating the scapula. *Nerve,* the fifth cervical. This muscle is often united with the following:

Rhomboideus Major (Figs. 285, 287).—"The larger rhomb-shaped muscle." *Situation,* in the back, between the spinal column and the scapula. *Origin,* the spinous processes of the upper four or five thoracic vertebræ and the corresponding supraspinous ligament. *Direction,* down- and outward. *Insertion,* the ver-

tebral border of the scapula, between the root of the spine and the lower angle. *Action*: it draws the scapula up- and inward. *Nerve*, the fifth cervical.

Serratus Magnus (Fig. 288).—"The great saw-toothed muscle." *Synonym*, serratus anterior. *Situation*, on the upper two-thirds of the side of the chest. *Origin*, by digitations from the outer surface of the upper eight or nine ribs,

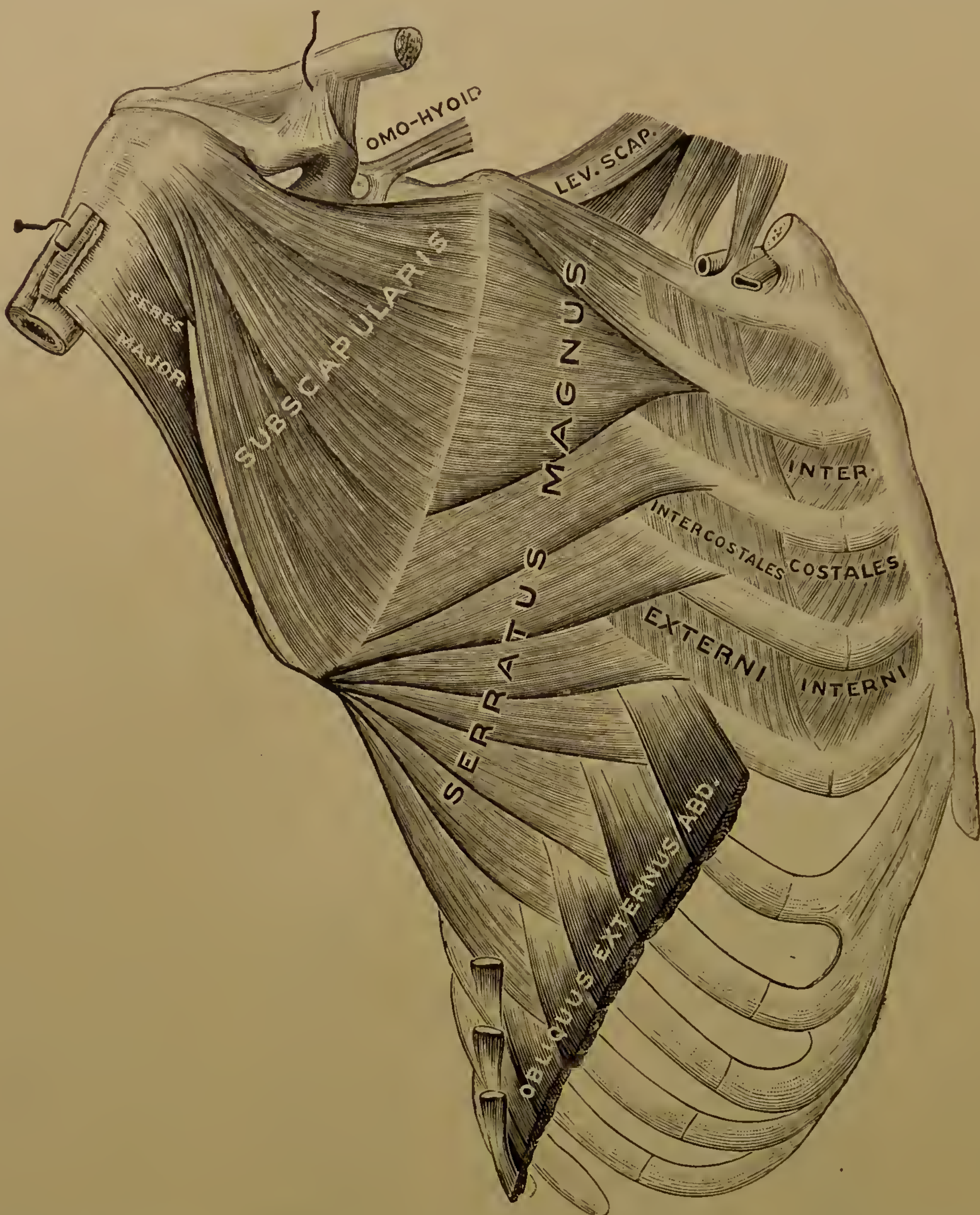

FIG. 288.—Serratus magnus of right side. The scapula has been turned backward and drawn outward. (Modified from Testut.)

several inches from their front ends. *Direction*, up- and backward. *Insertion*, the front of the vertebral border of the scapula, and the surfaces at the upper and lower angles. The first digitation, which comes from the second, as well as from the first rib, runs to the surface at the upper angle; the second and third digitations connect the corresponding ribs with the vertebral border from near the upper to near the lower angle; the rest of the slips converge to the surface at the lower angle. *Action*: it draws the shoulder forward, as in pushing; the lower segment rotates the apex of the scapula upward. *Nerve*, the posterior thoracic. The lower five points of origin interlock with similar slips of the obliquus externus abdominis.

Pectoralis Minor (Fig. 289, 290).—"The smaller breast-muscle." *Situation*, in the front of the chest. *Origin*, the outer surfaces of the third, fourth, and fifth ribs, near their cartilages. *Direction*, up- and outward. *Insertion*, the coracoid process of the scapula. *Action*: it draws the shoulder down- and forward. *Nerve*, the internal anterior thoracic.

Subclavius (Fig. 289).—"The under-the-clavicle muscle." *Situation,* indi-

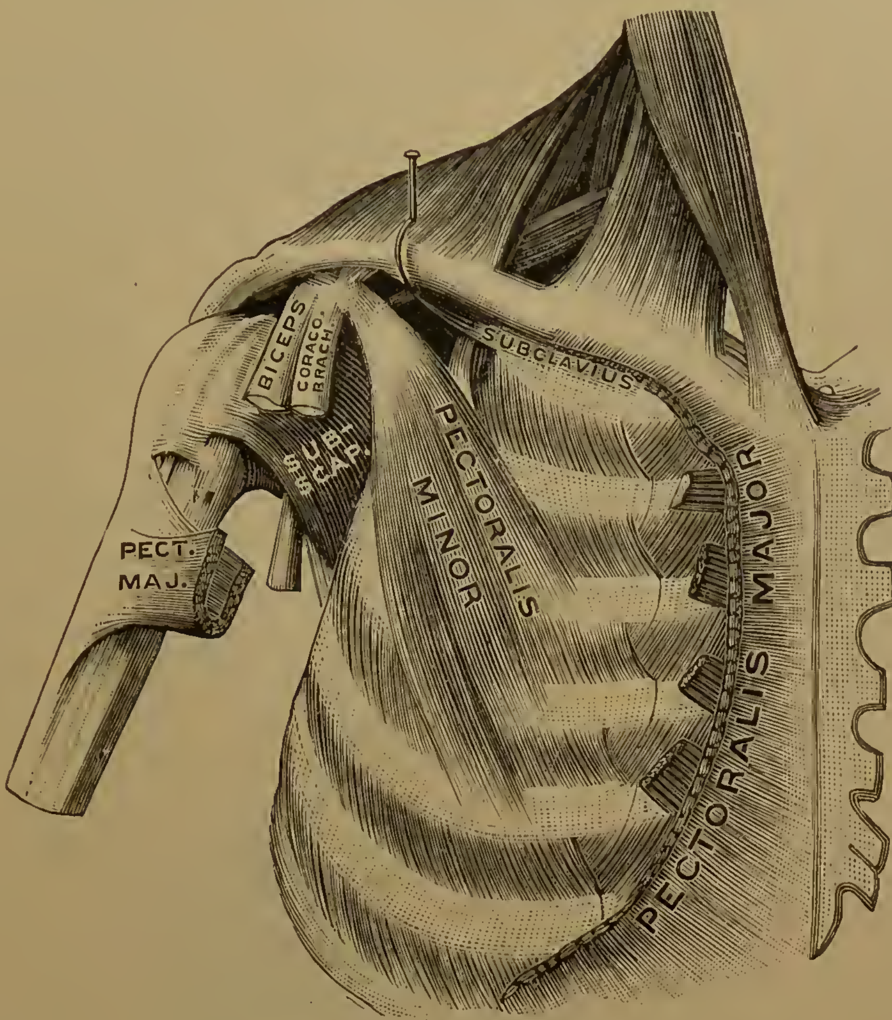

FIG. 289.—Pectoralis minor of right side. (Testut.)

cated by its name. *Origin,* the first rib and its cartilage, at their junction. *Direction,* out- and upward. *Insertion,* the groove in the under surface of the clavicle.

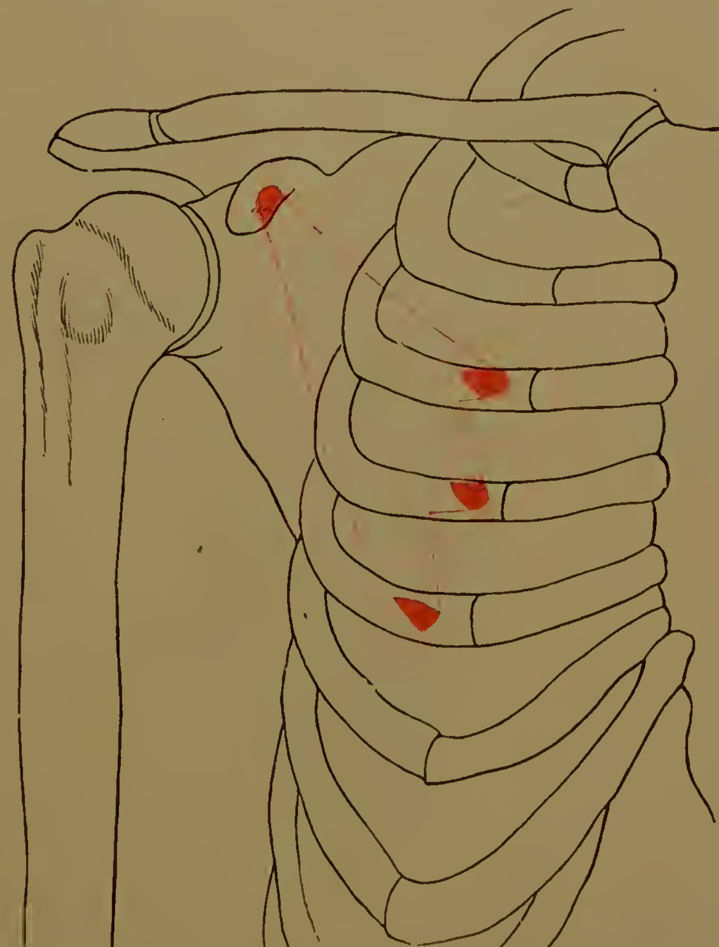

FIG. 290.—Pectoralis minor of right side: outline and attachment-areas. (F. H. G.)

Action: it draws the shoulder down- and forward. *Nerve,* from the fifth and sixth cervical.

MUSCLES MOVING THE ARM.

Abductors.	*Adductors.*
Deltoideus.	Pectoralis major. } *also flexors.*
Supraspinatus.	Coraco-brachialis. } *also flexors.*
	Latissimus. } *also extensors.*
	Teres major. } *also extensors.*

Outward Rotators.	*Inward Rotator.*
Infraspinatus.	Subscapularis.
Teres minor.	

The largest two of these muscles arise mostly from the trunk, and in some part from the shoulder; but the majority arise wholly from the shoulder. All of them are inserted into the humerus in its upper half.

Deltoideus (Figs. 291, 292, 309).—"The delta-like muscle"—"delta" being the name of a Greek letter of triangular shape. It is commonly Anglicized into "deltoid." *Situation*, between the most prominent parts of the shoulder and the

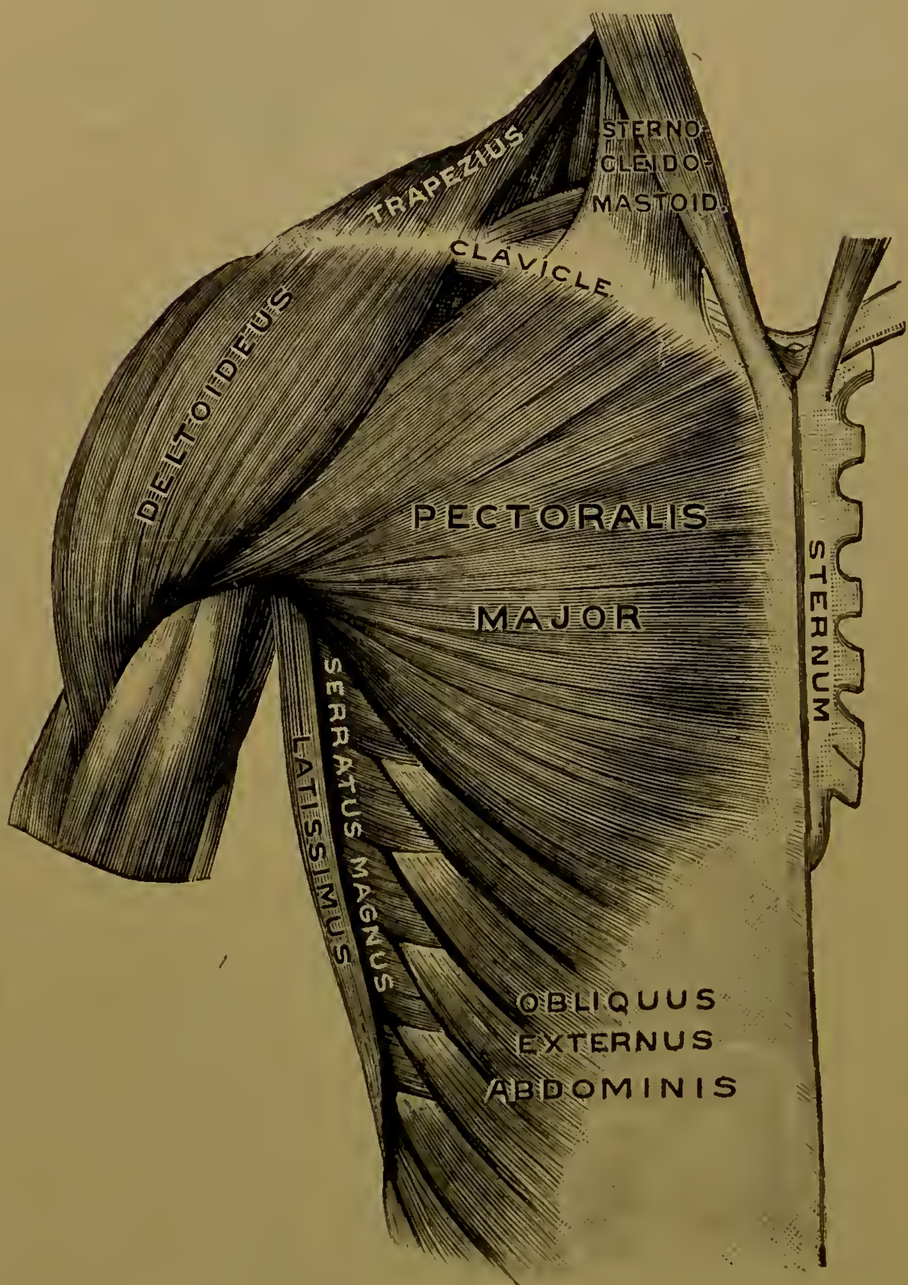

FIG. 291.—Front of chest and shoulder of right side, superficial muscles. (Testut.)

middle of the outside of the arm. *Origin*, the front of the outer third of the clavicle, the outer border of the acromion, and the lower border of the spine of

the scapula—corresponding closely with the insertion of the trapezius. *Direction*, from the clavicle and the scapular spine down- and outward, from the acromion

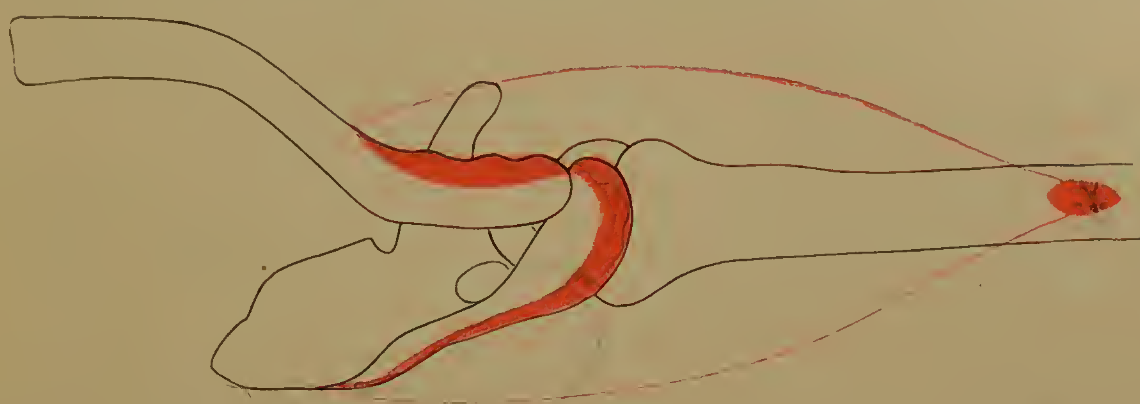

FIG. 292.—Deltoideus of right side, viewed from above: outline and attachment-areas. (F. H. G.)

downward—all parts converging. *Insertion*, the deltoid eminence (or impression) of the humerus. *Action*: it abducts the arm, lifting it to the horizontal. The

FIG. 293.—Supraspinatus of right side, viewed from above: outline and attachment-areas. (F. H. G.)

clavicular portion acting alone draws the arm forward; that from the scapular spine by itself carries the arm backward. The arm, being raised as far as the

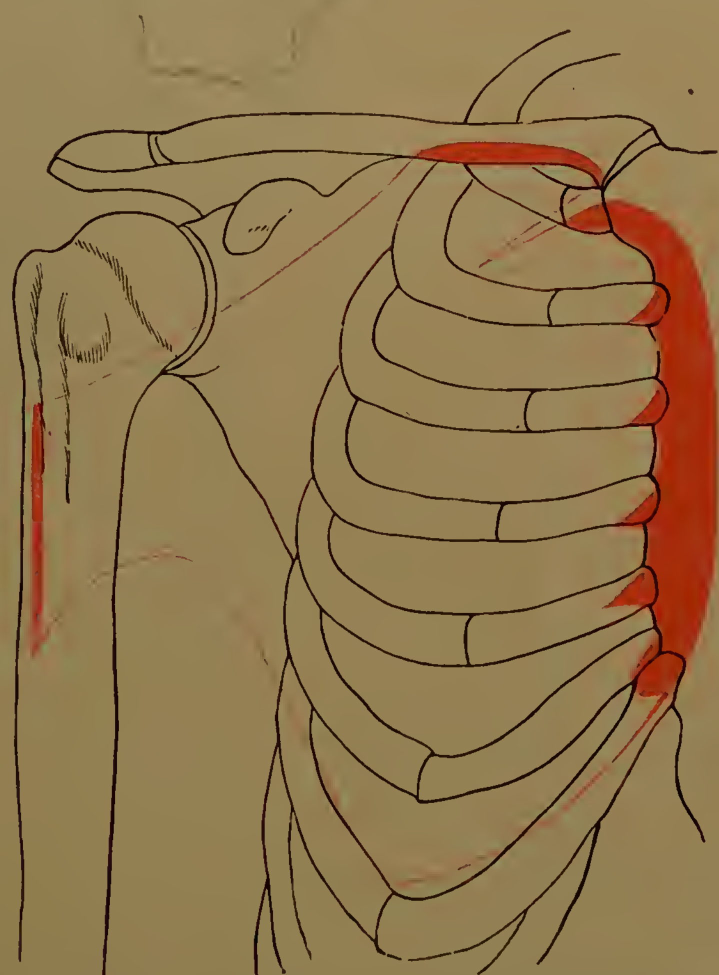

FIG. 294.—Pectoralis major of right side: outline and attachment-areas. (F. H. G.)

deltoid can affect it, is elevated to the perpendicular by the trapezius, the two muscles being almost continuous in structure—practically one muscle with an osseous inscription. *Nerve*, the circumflex.

Supraspinatus (Figs. 293, 298).—"The muscle above the spine" of the scapula. *Situation,* in the supraspinous fossa and above the head of the humerus. *Origin,* the inner two-thirds of the supraspinous fossa. *Direction,* outward beneath the acromion. *Insertion,* the uppermost facet of the great tuberosity of the humerus. *Action,* abduction of the arm. *Nerve,* the suprascapular.

Pectoralis Major (Figs. 291, 294).—"The greater breast-muscle." *Situation,* in the upper, anterior part of the chest, and in front of the axilla. *Origin,* the sternal half of the anterior surface of the clavicle, the anterior surface of the sternum (except the ensiform process), the cartilages of the upper six ribs. *Direction*: of the clavicular portion (which is separate at its origin) down- and outward; of the central, outward; of the lower, out- and upward—all parts converging to one broad tendon, which twists on itself, the lower fibres passing behind and becoming uppermost. *Insertion,* the external lip of the bicipital groove of the humerus. *Action:* it draws the arm inward and forward, and rotates it inward. *Nerves,* the internal and external anterior thoracic.

Fig. 295.—Coraco-brachialis of right side: outline and attachment-areas. (F. H. G.)

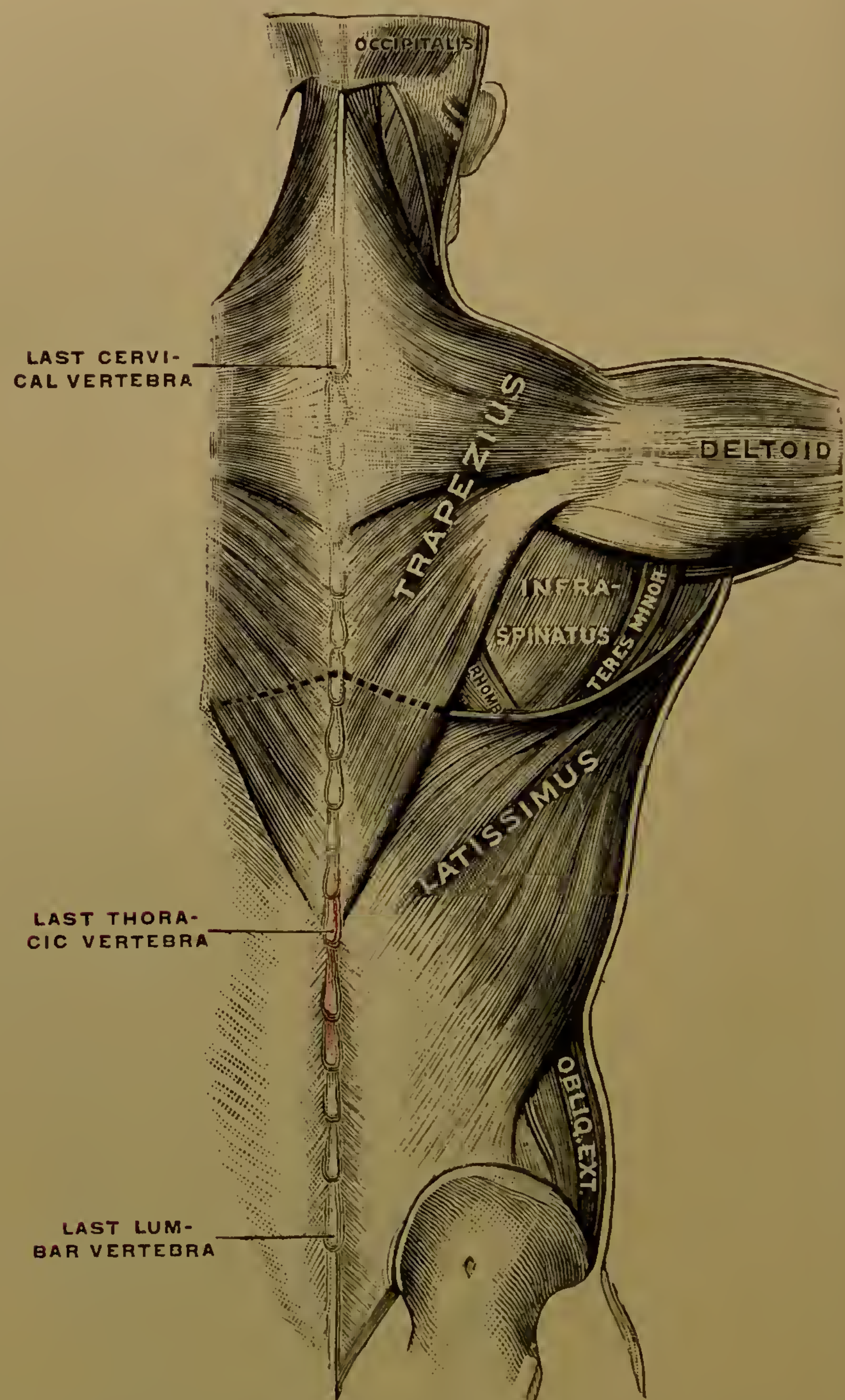

Fig. 296.—Muscles in the superficial layer of the back. (Testut.)

Coraco-brachialis (Figs. 295, 303, 305).—"The coracoid [process] arm muscle"—the name being derived from the parts connected. *Situation,* in the inner side of

the upper half of the arm. *Origin*, the coracoid process of the scapula. *Direction*, downward and slightly outward. *Insertion*, the inner border of the humerus at the middle of the shaft. *Action*, adduction and flexion of the arm. *Nerve*, the musculo-cutaneous.

Latissimus (Figs. 296, 297).—"The broadest muscle"—from the Latin *latus*, "broad." *Synonym*, latissimus dorsi, "the broadest of the back." *Situation*, in the back, from the lower half of the spine to the upper part of the arm. *Origin*, the spines of six or seven lower thoracic vertebræ, and, through the lumbar fascia, the spines of the lumbar and sacral, the back part of the outer lip of the iliac crest, the last three or four ribs, and often the lower angle of the scapula. *Direction*, upward, outward, and forward, converging to the insertion, the tendon twisting from above downward and backward, so that its front is continuous with the back of the muscle. *Insertion*, the floor of the bicipital groove. *Action*, adduction, extension, and rotation inward. *Nerve*, the long subscapular. The costal points of origin interlock with those of the obliquus externus abdominis.

Teres Major (Figs. 298, 299).—"The greater round muscle." *Situation*, between the scapula and the upper end of the arm, in the hind wall of the armpit. *Origin*, the oval surface on the back of the scapula at its lower angle. *Direction*, up-, out-, and forward. *Insertion*, the inner lip of the bicipital groove. *Action*, adduction, extension, and inward rotation of the arm. *Nerve*, the lower subscapular.

Infraspinatus (Figs. 298, 300).—"The muscle below the spine" of the scapula. *Situation*, in the infraspinous fossa and behind the head of the humerus. *Origin*, the inner two-thirds of the infraspinous fossa. *Direction*, outward. *Insertion*, the middle facet of the great tuberosity of the humerus. *Action*, external rotation of the arm. *Nerve*, the suprascapular.

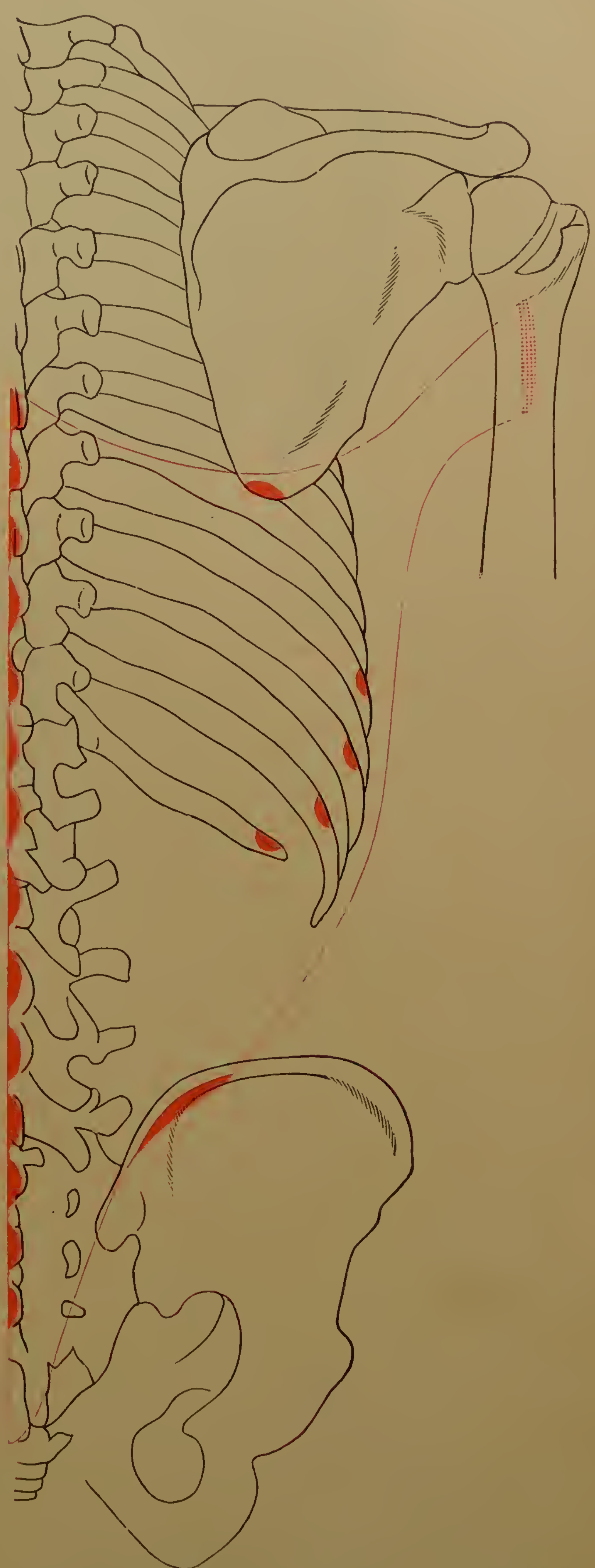

FIG. 297.—Latissimus of right side: outline and attachment-areas. (F. H. G.)

Teres Minor (Figs. 298–301).—"The smaller round muscle." *Situation*, between the scapula and the upper end of the arm, in the hind wall of the arm-

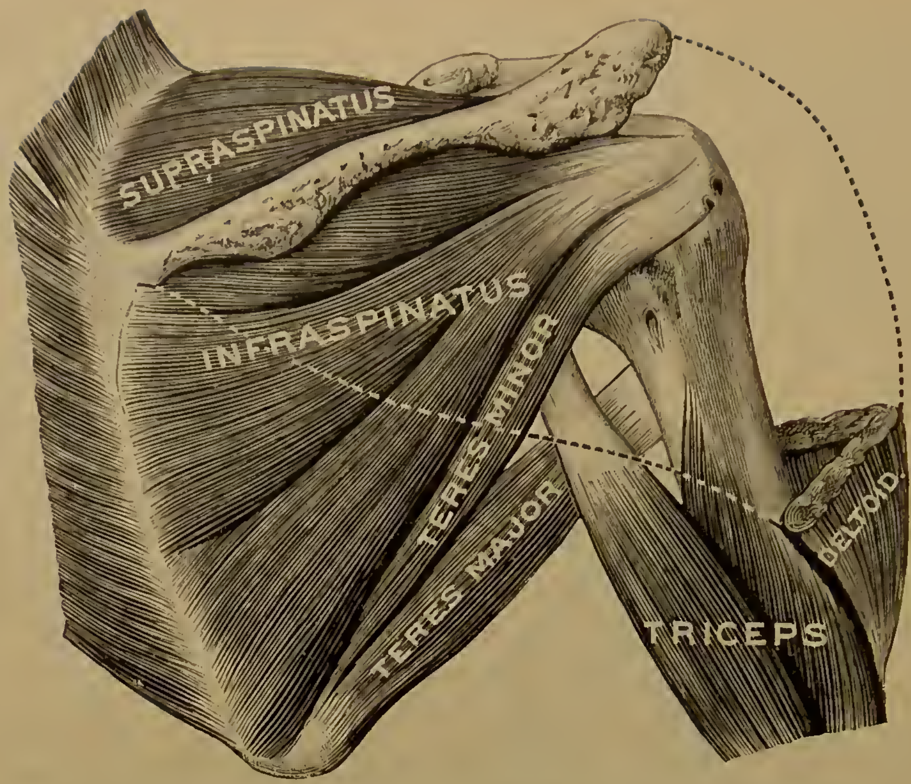

FIG. 298.—Muscles of the dorsum of the scapula, right side. (Testut.)

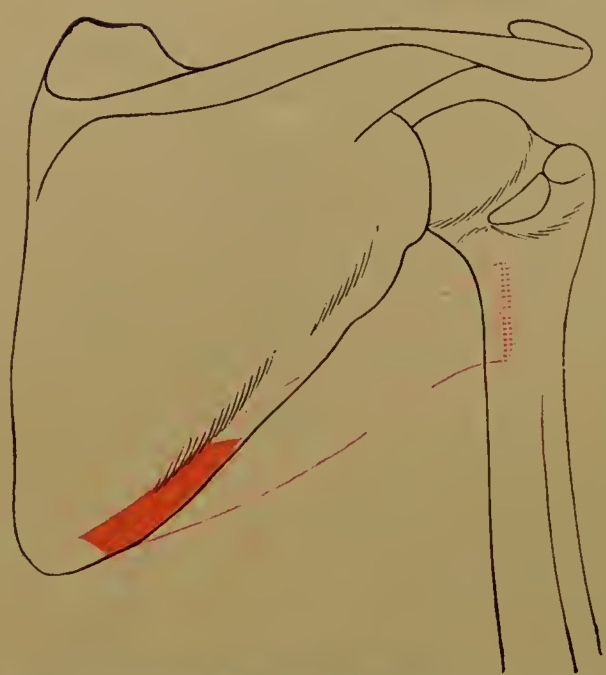

FIG. 299.—Teres major of right side: outline and attachment-areas. (F. H. G.)

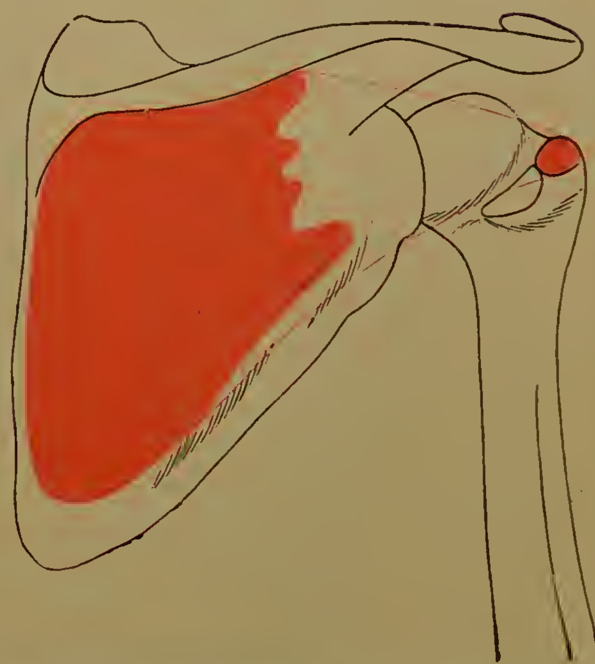

FIG. 300.—Infraspinatus of right side: outline and attachment-areas. (F. H. G.)

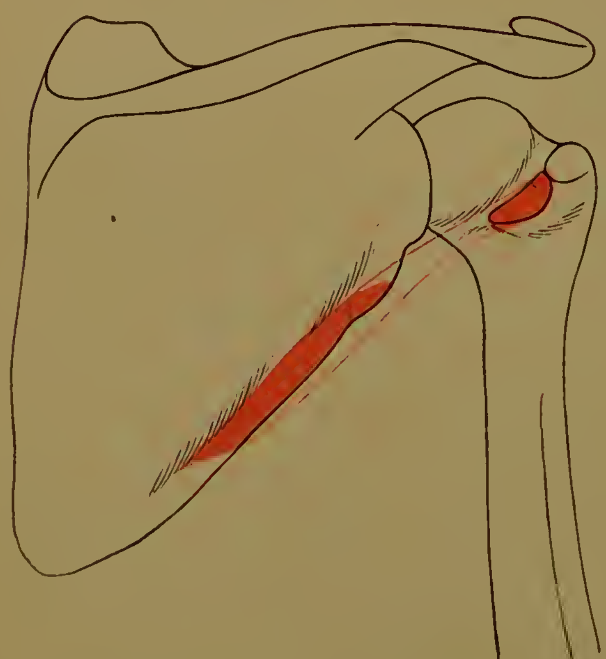

FIG. 301.—Teres minor of right side: outline and attachment-areas. (F. H. G.)

FIG. 302.—Subscapularis of right side: outline and attachment-areas. (F. H. G.)

pit. *Origin,* the dorsum of the scapula, along its axillary border. *Direction,* upward and outward. *Insertion,* the lowest facet on the great tuberosity of the humerus. *Action,* external rotation of the humerus. *Nerve,* the circumflex.

Subscapularis (Figs. 282, 283).—"The muscle under the scapula"—though it is beneath the bone only when the body is prone. *Situation,* in front of the scapula and the head of the humerus. *Origin,* the greater part of the venter of the scapula. *Direction,* outward and forward. *Insertion,* the small tuberosity of the humerus. *Action,* inward rotation of the humerus. *Nerves,* the upper and lower subscapular.

MUSCLES MOVING THE WHOLE FOREARM.

Flexors.	*Extensors.*
Biceps flexor cubiti.	Triceps extensor cubiti.
Brachialis.	Anconeus.
Brachio-radialis.	

One of these muscles arises from the scapula, one from the scapula and humerus, and three from the humerus alone. All are inserted into the skeleton of the forearm.

FIG. 303.—Muscles of the front of the right shoulder and arm. (Testut.)

FIG. 304.—Biceps flexor cubiti of right side: outline and attachment-areas. (F. H. G.)

Biceps Flexor Cubiti (Figs. 303, 304).—"The two-headed flexor of the fore-

arm." *Situation*, in the front of the arm. *Origin*, the scapula—the long head: the upper border of the glenoid fossa; the short head: the coracoid process. *Direction*, the long head: over the caput humeri, through the shoulder-joint, in the bicipital groove, and down to the forearm; the short head unites with the long about one-fourth way down the arm. *Insertion*, the main tendon to the hind part of the bicipital tuberosity of the radius; a secondary tendon (called also the semilunar or bicipital fascia) passes obliquely inward, and ends in the deep fascia of the forearm over the pronator teres. *Action*, flexion of the forearm. If the hand is pronated, the biceps supinates it. The second tendon of insertion tightens the forearm-fascia. *Nerve*, the musculo-cutaneous. The synovial membrane of the shoulder-joint is prolonged downward, and invests the tendon of the long head.

Brachialis (Figs. 305, 306).—"The muscle of the arm." *Synonyms*, brachialis anterior, brachialis anticus, "the front muscle of the arm." *Situation*, in the front

Fig. 305.—Muscles of the right arm, front view, the biceps having been removed. (Testut.)

Fig. 306.—Brachialis of right side: outline and attachment-areas. (F. H. G.)

of the arm. *Origin*, the lower half of the external and internal surfaces and ventral border of the humerus. *Direction*, downward to the forearm. *Insertion*, the inner

part of the coronoid process of the ulna. *Action,* flexion of the forearm. *Nerves,* the musculo-cutaneous and (slightly) the musculo-spiral.

Brachio-radialis (Figs. 307, 308, 323).—"The arm-radius muscle," from its attachments. *Synonym,* supinator longus, "the long supinator." *Situation,* the outer and front part of the lower fourth of the arm and of the whole forearm. *Origin,* the upper two-thirds of the external supracondylar ridge of the humerus.

Fig. 307.—Superficial muscles of front of right forearm. (Testut.)

Fig. 308.—Brachio-radialis of right side, outside view: outline and attachment-areas. (F. H. G.)

Direction, downward. *Insertion,* the base of the styloid process of the radius. *Action,* mostly flexion of the forearm; but, when the hand is prone, this muscle is capable of nearly half-supinating it; after strong supination, the muscle will partially effect pronation. *Nerve,* the musculo-spiral.

Triceps Extensor Cubiti (Figs. 309, 311).—"The three-headed extensor of the forearm." *Situation,* in the back of the arm. *Origin,* the long (middle) head: below the glenoid fossa of the scapula on the neck and upper part of the axillary border; the external head: the hind surface of the humerus above the musculo-spiral groove; the internal (deep) head: the hind surface of the humerus below the musculo-spiral groove. *Direction,* downward, all the heads uniting in a com-

mon tendon. *Insertion*, the back of the upper part of the olecranon process of the ulna and, by a few fibres, the posterior ligament of the elbow-joint. This small part is sometimes called the *subanconeus muscle*. *Action*, extension of forearm. *Nerve*, the musculo-spiral.

Anconeus (Figs. 309, 312, 330).—"The elbow muscle." *Situation*, at the back and outer side of the elbow-joint, mostly in the forearm. *Origin*, the hind part

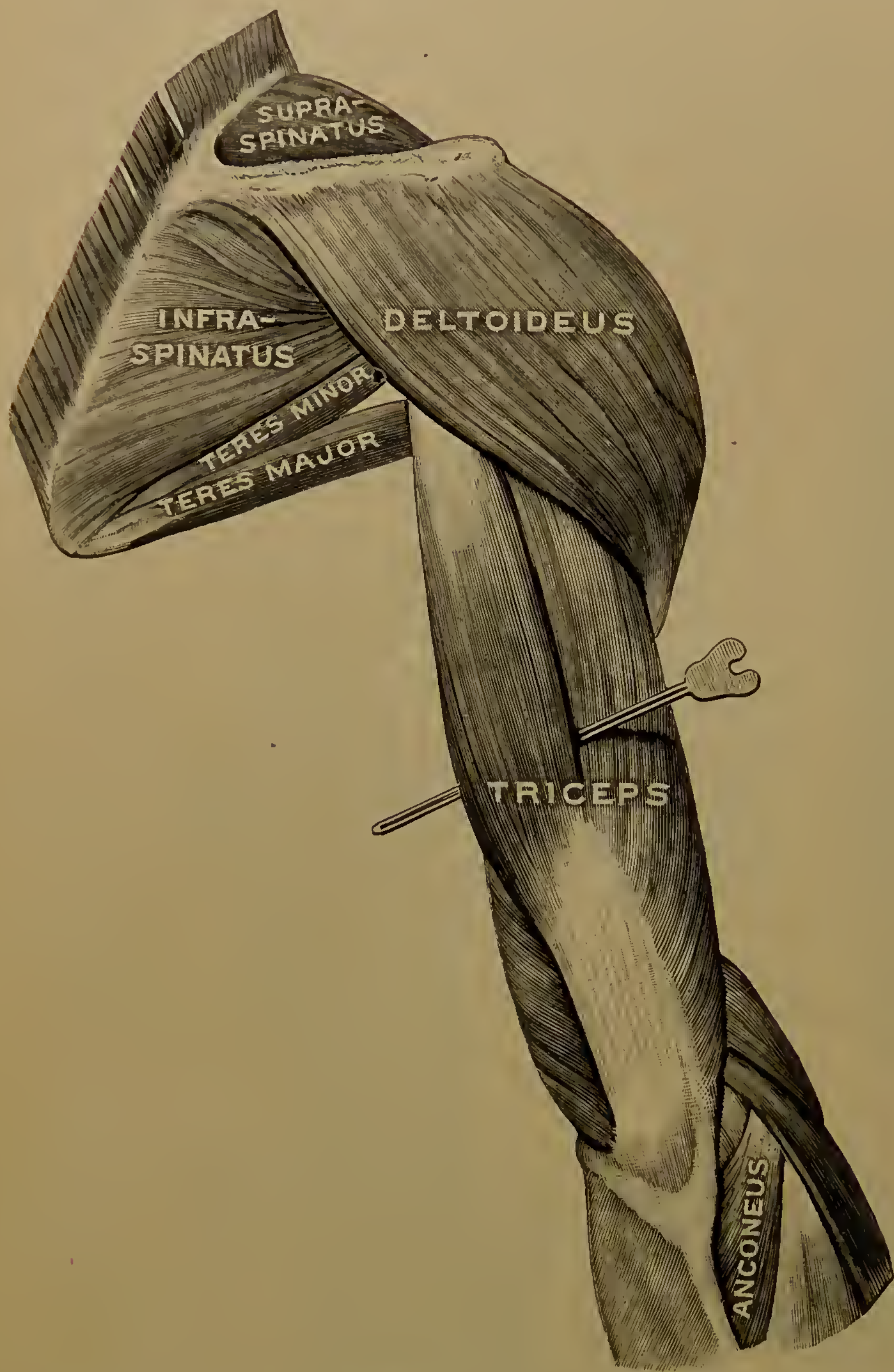

FIG. 309.—Muscles on the dorsum of the right shoulder and arm. (Testut.)

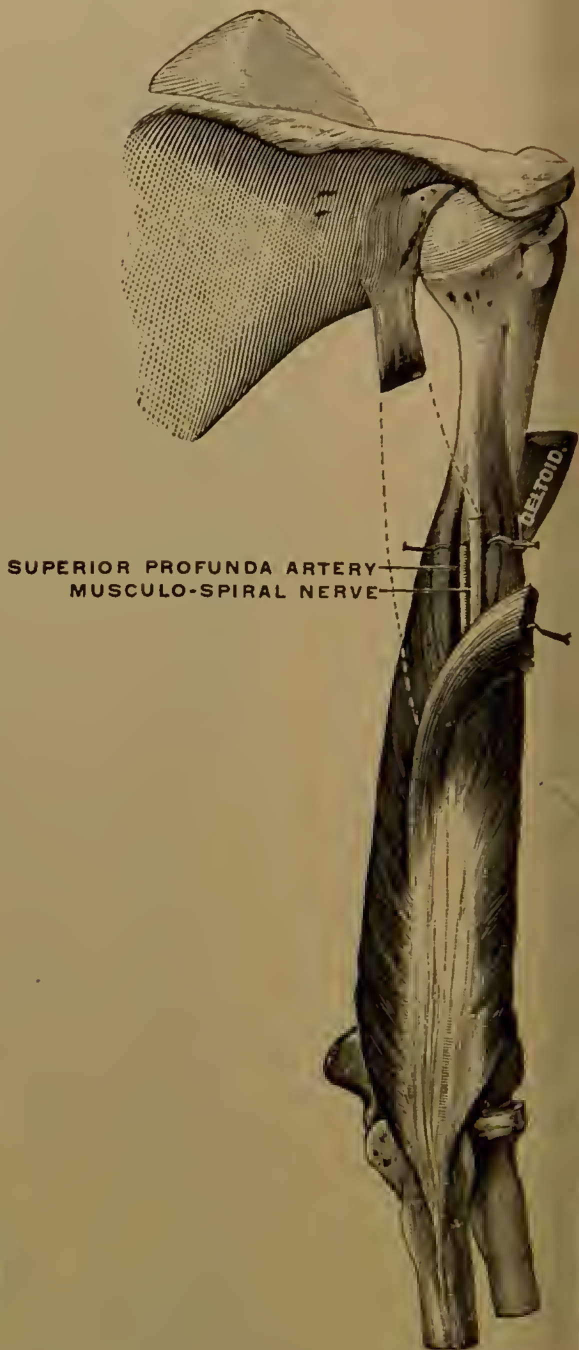

FIG. 310.—Triceps extensor cubiti of right side: part of the scapular head has been removed and shows in outline. (Testut.)

of the external condyle of the humerus. *Direction*, obliquely downward. *Insertion*, the outer side of the olecranon process, and the upper fourth of the dorsal surface of the shaft of the ulna. *Action*, extension of the forearm. *Nerve*, the musculo-spiral. The anconeus is a continuation of the triceps, and is sometimes described as the fourth head of the latter, thus converting it into a quadriceps, or four-headed muscle.

MUSCLES MOVING THE OUTER PART OF THE FOREARM.

Pronators.	*Supinator.*
Pronator teres.	Supinator.
Pronator quadratus.	

Of the pronators, one arises from the humerus and ulna, the other from the ulna

only. The supinator arises from the humerus and the ulna. All are inserted into the radius, which alone of the forearm bones is moved in pronation and supination.

Pronator Teres (Figs. 307, 313).—"The round pronator." *Situation*, in the front of the forearm. *Origin*, the superficial head: the inner condyle of the humerus and a small part of the ridge above it; the deep-head: the inner border of the coronoid process of the ulna. *Direction*, out- and downward. *Insertion*, the middle of the outer surface of the radius. *Action*, pronation

FIG. 311.—Triceps extensor cubiti of right side: outline and attachment-areas. (F. H. G.)

FIG. 312.—Anconeus of right side: outline and attachment-areas. (F. H. G.)

of the hand by moving the radius to which the hand is articulated; also slight flexion of the forearm. *Nerve*, the median.

Pronator Quadratus (Figs. 314, 338).—"The square pronator." *Situation*, in the lower quarter of the front of the forearm, close to the bones. *Origin*, the

inner part of the lower fourth of the front surface of the shaft of the ulna. *Direction*, outward. *Insertion*, the lower fourth of the front of the radius. *Action*, pronation of the radius, and, consequently, of the hand. *Nerve*, the anterior interosseous branch of the median.

FIG. 313.—Pronator teres, right side: outline and attachment-areas. (F. H. G.)

FIG. 114.—Pronator quadratus of right side: outline and attachment-areas. (F. H. G.)

Supinator (Fig. 305).—"The supinator." *Synonym*, supinator brevis, "the short supinator." *Situation*, deep in the upper third of the outer part of the forearm. *Origin*, the back and lower part of the external condyle of the humerus, the external lateral and orbicular ligaments, the triangular area below the small sigmoid cavity. *Direction*, out- and downward, wrapping the upper part of the radius in a sling. *Insertion*, the back of the neck, and the hind and outer surfaces of the shaft of the radius above the oblique line. *Action*, supination. *Nerve*, the posterior interosseous division of the musculo-spiral.

MUSCLES MOVING THE WHOLE HAND.

Flexors.	*Extensors.*
Flexor carpi radialis.	Extensor carpi radialis longus.
[Flexor] palmaris longus.	Extensor carpi radialis brevis.
Flexor carpi ulnaris.	Extensor carpi ulnaris.

All arise from the humerus, and the flexor and extensor on the ulnar side come from the ulna also. The palmaris longus is inserted into the palmar fascia. All which have "carpi" in their names are inserted into *meta*carpal bones, and only one of them into any part of the carpus also. Their action, however, is correctly indicated by their names, the wrist, carrying the rest of the hand, being alternately flexed and extended. The second, third, and fourth metacarpal bones have practically no motion on the carpus, and the first and fifth are moved by special muscles. The palmaris longus, though primarily a tensor of the palmar fascia, secondarily is a flexor of the hand —just as the tensor vaginæ femoris is first a tightener of the fascia lata, and then an abductor of the thigh—and, therefore, a bracketed word implying this, and aiding the grouping by making a uniformity of name which corresponds with the practical identity of action, has been prefixed. The adduction of the hand is accomplished by the simultaneous action of the flexor carpi ulnaris and the extensor carpi ulnaris ; its abduction by the simultaneous action of the flexor carpi radialis and the extensor carpi radialis longus. Observe that the *ex*ternal part of the lower end of the humerus gives origin to the *ex*tensors, the internal to the flexors. At their origin from the internal condyle and its neighborhood the flexors of the hand are so blended with the pronator teres and the flexor sublimis digitorum as to constitute one mass. On and about the external condyle is a similar association of extensors and supinator.

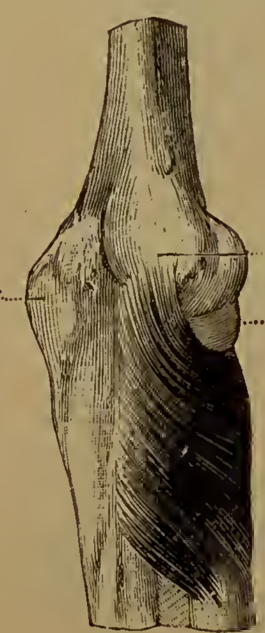

FIG. 315.—Supinator of right side. (Testut.)

Flexor Carpi Radialis (Figs. 316, 317).—"The flexor of the wrist on the radial side." *Situation*, in the front of the forearm. *Origin*, the inner condyle of the humerus. *Direction*, downward and a little outward. *Insertion*, the base of the second metacarpal bone on its palmar aspect. *Action*, flexion and slight pronation of the hand. In conjunction with the extensor carpi radialis longus it abducts the hand. *Nerve*, the median.

[Flexor] Palmaris Longus (Fig. 316).—"The long palmar [flexor] muscle." *Situation*, in the front of the forearm. *Origin*, the inner condyle of the humerus. *Direction*, downward and slightly outward. *Insertion*, the palmar fascia and anterior annular ligament. *Action* : it tightens the fascia of the palm, and then flexes the hand. *Nerve*, the median.

Flexor Carpi Ulnaris (Figs. 316, 318, 330).—"The flexor of the wrist on the ulnar side." *Situation*, in the front and inner border of the forearm. *Origin*, one head : the inner condyle of the humerus ; the other head : the inner side of the olecranon and the upper two-thirds of the dorsal border of the ulna. The origin from the dorsal border of the ulna is by a tendon common to this muscle and the extensor carpi ulnaris and the flexor profundus digitorum. *Direction*, downward. *Insertion*, the pisiform, unciform, and the base of the fifth metacarpal. *Action*, flexion of the hand. In conjunction with the extensor carpi ulnaris it adducts the hand. *Nerve*, the ulnar.

Extensor Carpi Radialis Longus (Figs. 319, 320).—"The long extensor of the wrist on the radial side." *Situation*, in the outer border of the forearm. *Origin*, the lower third of the external supracondylar ridge of the humerus. *Direc-*

tion, downward and a little backward. *Insertion,* the base of the second metacarpal, behind and on the radial side. *Action,* extension of the hand. In conjunction with the flexor carpi radialis it abducts the hand. *Nerve,* the musculo-spiral.

FIG. 316.—Superficial muscles of front of right forearm. (Testut.)

FIG. 317.—Flexor carpi radialis of right side: outline and attachment-areas. (F. H. G.)

FIG. 318.—Flexor carpi ulnaris of right side: outline and attachment-areas. (F. H. G.)

Extensor Carpi Radialis Brevis (Figs. 319–321).—"The short extensor of the wrist on the radial side." *Situation,* the outer border of the forearm. *Origin,* the outer condyle of the humerus. *Direction,* downward and a little backward. *Insertion,* the base of the third metacarpal bone, behind and on the radial side. *Action,* extension of the hand. *Nerve,* the posterior interosseus branch of the musculo-spiral.

Extensor Carpi Ulnaris (Figs. 322, 330).—"The extensor of the wrist on the ulnar side." *Situation,* the back of the forearm on the ulnar side. *Origin,* the

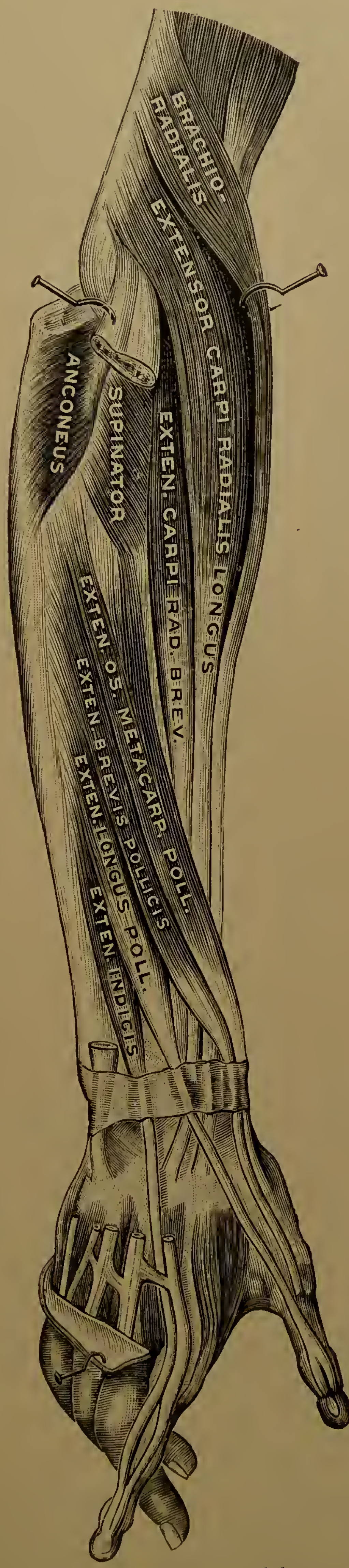

FIG. 319.—Muscles in radial region of right forearm, and deep muscles in its dorsum. (Testut.)

external condyle of the humerus and the middle third of the dorsal border of the ulna by the tendon common to it, the ulnar flexor, and the deep flexor of the fingers. *Direction*, downward and inward. *Insertion*, the base of the fifth meta-

FIG. 320.—Extensor carpi radialis longus of right side: outline and attachment-areas. (F. H. G.)

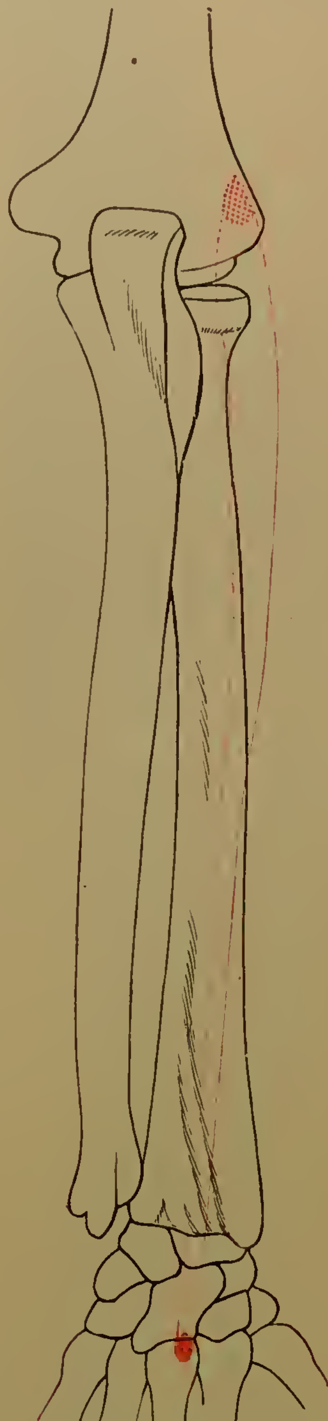

FIG. 321.—Extensor carpi radialis brevis of right side: outline and attachment-areas. (F. H. G.)

FIG. 322.—Extensor carpi ulnaris of right side: outline and attachment-areas. (F. H. G.)

carpal bone on its dorsal aspect and ulnar border. *Action*, extension of the hand. In conjunction with the flexor carpi ulnaris it adducts the hand. *Nerve*, the posterior interosseous branch of the musculo-spiral.

MUSCLES MOVING THE FINGERS
and the Fifth Metacarpal Bone.

(Those which are situated entirely in the hand are indicated by a star.)

Flexors.	*Extensors.*
Flexor sublimis digitorum.	Extensor communis digitorum.
Flexor profundus digitorum.	Extensor minimi digiti.
*Flexor ossis metacarpi minimi digiti.	Extensor indicis.
*Flexor brevis minimi digiti.	
*Lumbricales.	

Abductors.	*Adductors.*
*Interossei dorsales.	*Interossei palmares.
*Abductor minimi digiti.	

Of the five of these muscles located mainly in the forearm two arise from the humerus, one from the humerus, radius, and ulna, and two from the ulna only. Every one in the group is inserted into one or more of the fingers, excepting the flexor of the fifth metacarpal bone, which is admitted to this company of finger flexors on account of the similarity of its action.

Flexor Sublimis Digitorum (Figs. 323–325).—"The superficial flexor of the digits"—meaning the four fingers as distinguished from the thumb. *Synonym,* flexor perforatus, "the perforated flexor"—from the openings through which the tendons of the deep flexor pass. *Situation,* in the front of the forearm and hand, deeper than the flexors of the whole hand, but superficial to the other flexors. *Origin,* first head: the inner condyle of the humerus; second head: the inner border of the coronoid process of the ulna; third head: the oblique line and part of the anterior border of the radius. *Direction,* downward to all of the digits but the thumb. *Insertion,* by four tendons, each to the sides of a second phalanx. As the tendons pass through the annular ligament, those for the middle and ring-fingers are side by side in front, the others behind them. Each tendon

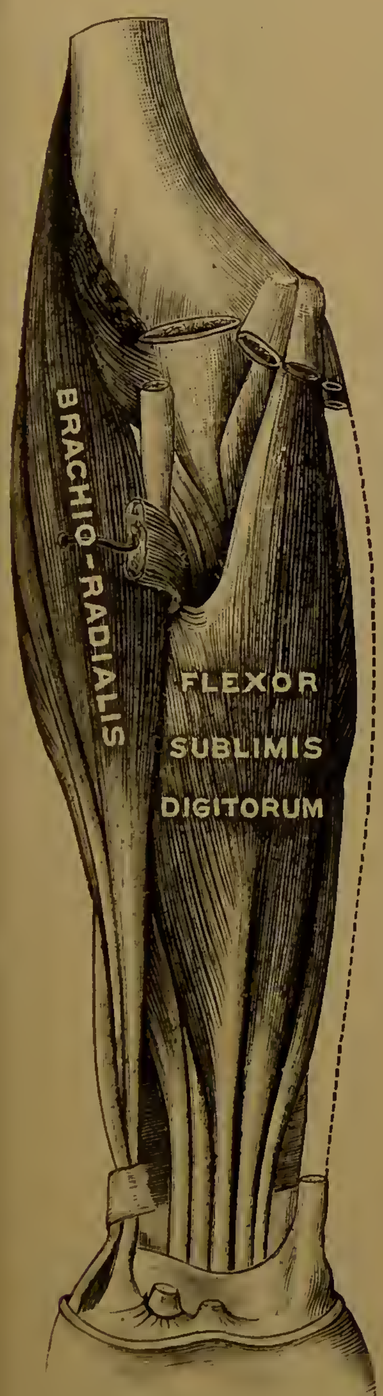

FIG. 323.—Flexor sublimis digitorum of right side. (Testut.)


FIG. 324.—Flexor sublimis digitorum of right side: outline and attachment-areas. (F. H. G.)

FIG. 325.—Tendon of flexor sublimis perforated by tendon of flexor profundus. (Testut.)

is accompanied by a tendon of the flexor profundus, and permits the passage of the latter through a split which occurs opposite the first phalanx. The separated halves become united behind the tendon of the deep flexor, opposite the base of the second phalanx, but almost immediately separate again, and are inserted into the sides of the second phalanx. The tendons are bound down to the phalanges by a ligamentous sheath. *Action*, primary, flexion of the second phalanges; secondary, flexion of first phalanges. *Nerve*, the median.

Flexor Profundus Digitorum (Figs. 326–328).—"The deep flexor of the digits"—meaning the fingers as distinguished from the thumb. *Synonym*, flexor perforans, "the perforating flexor"—from the fact that its four tendons perforate the corresponding tendons of the flexor sublimis. *Situation*, deep in the front of the forearm and hand. *Origin*, three-fourths of the internal and ventral surfaces of the ulna, the adjacent half of the interosseous membrane, and the common tendon of it and the flexor and extensor carpi ulnaris on the hind border of the ulna. *Direction*, downward. *Insertion*, each of the four tendons into the front of the base of a last phalanx. Each tendon perforates a tendon of the superficial flexor opposite the first phalanx of the finger to which it belongs; each is bound to the first and second phalanges by ligaments which form a sheath common to this and the sublimis tendon. *Action*, flexion of third phalanges primarily, and, after this, flexion of the second, and, slightly, of the first. *Nerves*, the ulnar and the anterior interosseous branch of the median.

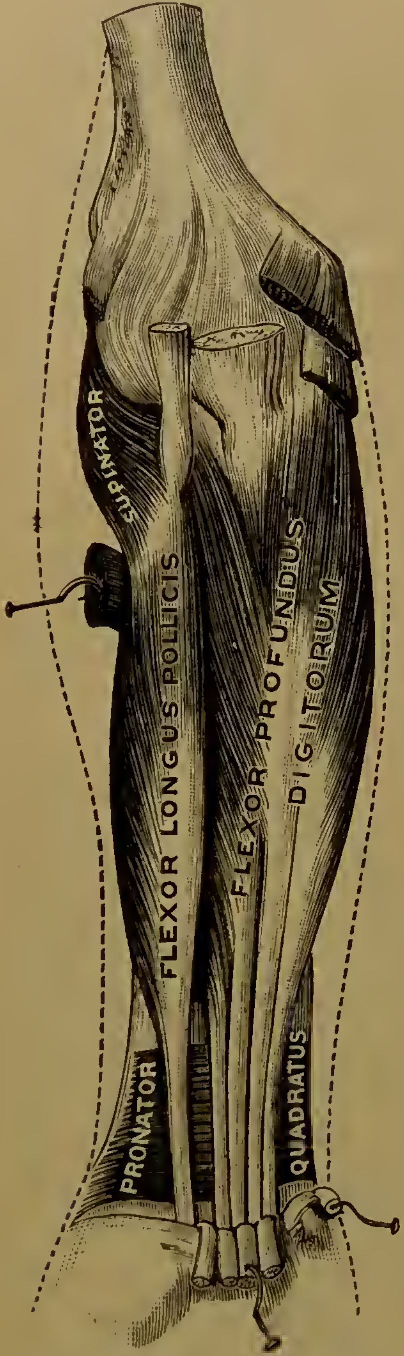

FIG. 326.—Muscles in the right forearm, the deepest layer. (Testut.)

FIG. 327.—Flexor profundus digitorum of right side: outline and attachment-areas. (F. H. G.)

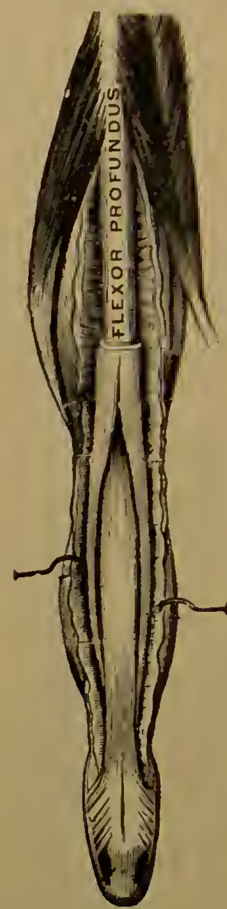

FIG. 328.—Tendon of flexor profundus perforating tendon of flexor sublimis. (Testut.)

Flexor Ossis Metacarpi Minimi Digiti (Fig. 329).—"The flexor of the metacarpal bone of the least digit"—*i. e.*, of the little finger. *Synonyms*, opponens minimi digiti, and opponens digiti quinti, "the opposing muscle of the least (or fifth) digit," so called from its drawing the hypothenar eminence toward the thenar, thus narrowing and deepening the palm. *Situation*, deep in the hypo-

FIG. 329.—Muscles of the right palm. The abductors of the thumb and little finger have been removed. (Testut.)

thenar eminence. *Origin*, the unciform process and the annular ligament. *Direction*, downward and toward the ulnar margin of the hand. *Insertion*, the whole of the ulnar side of the fifth metacarpal. *Action*, flexion of the fifth metacarpal and slight adduction toward the mid-line of the hand. *Nerve*, the deep branch of the ulnar.

Flexor Brevis Minimi Digiti (Fig. 329).—"The short flexor of the least digit"—*i. e.*, of the little finger. *Synonym*, flexor digiti quinti brevis, "the short flexor

of the fifth digit." *Situation*, subcutaneously in the centre of the hypothenar eminence. *Origin*, the unciform process and the annular ligament. *Direction*, downward and inward. *Insertion*, the base of the first phalanx of the little finger on the ulnar border. *Action*, flexion of the first phalanx of the little finger. *Nerve*, the deep branch of the ulnar.

Lumbricales (Fig. 329).—"The earthworm muscles," from their fancied resemblance to angle-worms (*lumbrici*). *Number*, four. Each is a lumbricalis. *Situation*, in the palm on the plane of the flexor profundus digitorum. *Origin* of the first and second: the palmar aspect and radial border of the corresponding deep flexor tendon; of the third and fourth: the two tendons between which

FIG. 330.—Muscles in the dorsum of the right forearm and hand. (Testut.)

FIG. 331.—Extensor communis digitorum of right side: outline and attachment-areas. (F. H. G.)

each respectively lies. *Direction*, downward and then backward, on the radial side of the digits. *Insertion*, each to the extensor communis tendon of the corresponding finger on the radial side of the first phalanx (Fig. 332). *Action*, flexion of the first phalanges, and extension of the second and third phalanges. The first and second slightly abduct the index and middle fingers from the middle line of the hand, the third and fourth slightly adduct the ring and little fingers to that line. *Nerves*, the median for the outer two, the ulnar for the inner two.

Extensor Communis Digitorum (Figs. 330, 332).—"The common extensor of the digits"—*i. e.*, of the fingers, as distinguished from the thumb. *Situation*, superficial on the back of the forearm and hand. *Origin*, the outer condyle of the humerus. *Direction*, downward. *Insertion* : each of the four tendons finally divides into three slips opposite the first phalanx, and the middle one is attached to the back of the base of the second phalanx ; the others, after uniting, are attached to the back of the base of the third phalanx. The first tendon receives the insertion of the extensor indicis at the base of the finger ; the fourth tendon unites with that of the extensor minimi digiti at a similar point. The fourth divides : one part unites with the tendon of the medius, the other with that of the extensor minimi digiti. A strong band runs obliquely downward and outward from the third to the second tendon, and a slighter, transverse band connects the first and second tendons. *Action*, extension of the fingers. The oblique branches at the sides of the third tendon greatly limit the extension of the ring finger, when its immediate

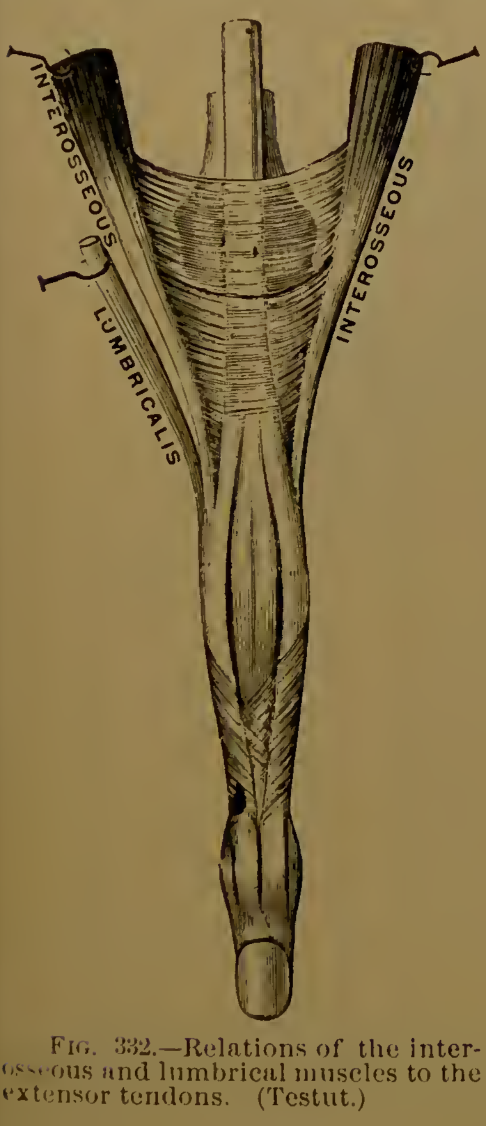

FIG. 332.—Relations of the interosseous and lumbrical muscles to the extensor tendons. (Testut.)

FIG. 333.—Extensor minimi digiti of right side: outline and attachment-areas. (Testut.)

FIG. 334.—Extensor indicis of right side: outline and attachment-areas. (F. H. G.)

neighbors are flexed, and this fact explains the difficulty experienced by pianists in lifting the annularis separately from the keys. *Nerve,* the posterior interosseous branch of the musculo-spiral.

Extensor Minimi Digiti (Figs. 330–333).—"The extensor of the smallest digit"—*i. e.,* of the little finger. *Synonym,* extensor digiti quinti proprius, "the proper extensor of the fifth digit"—"proper" to distinguish it from the part of the extensor communis which acts upon this finger. *Situation,* in the back of the forearm and hand. *Origin,* the external condyle of the humerus. *Insertion*: its tendon, which is commonly split, blends with the fourth tendon of the extensor communis above the metacarpo-phalangeal joint, and the resulting tendon goes to the second and third phalanges of the little finger (see extensor communis digitorum). *Action,* extension of the second and third phalanges of the little finger. *Nerve,* the posterior interosseous branch of the musculo-spiral.

Extensor Indicis (Figs. 319, 334).—"The extensor of the index finger." *Synonyms,* extensor indicis proprius, "the proper extensor of the index finger"—"proper" to distinguish it from the part of the extensor communis which acts upon this digit; the indicator muscle. *Situation,* the back of the lower part of the forearm and hand. *Origin,* the back of the ulna below the extensor longus pollicis, and a little of the interosseous membrane. *Direction,* downward and outward. *Insertion,* the first tendon of the extensor communis digitorum, near the metacarpo-phalangeal joint (see extensor communis digitorum). *Action,* extension and slight adduction of the index. *Nerve,* the posterior interosseous branch of the musculo-spiral.

Interossei Dorsales (Fig. 335).—"The muscles between the bones on the back"

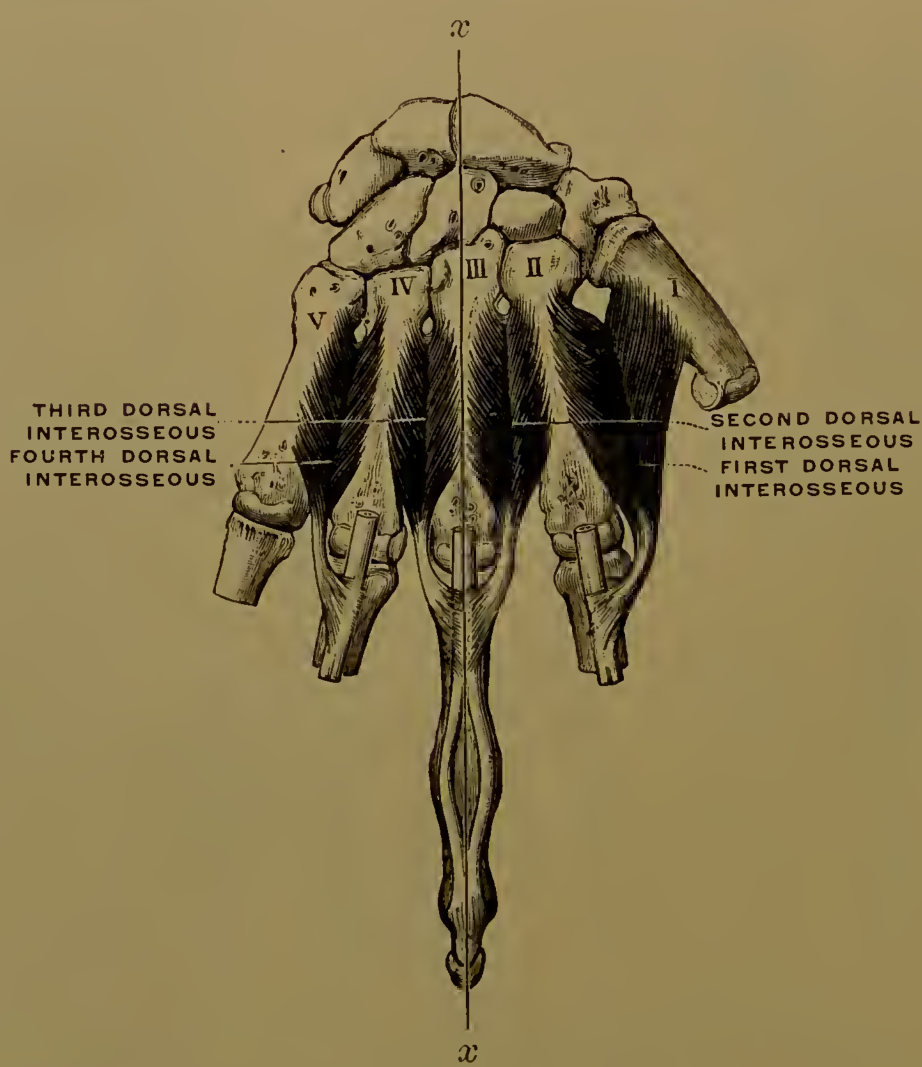

FIG. 335.—Interossei dorsales of right hand. The line *x x* is that from which abduction is made. (Testut.)

of the hand. *Number,* four. The first and largest is called *abductor indicis,* "the abductor of the index finger." The abductor minimi digiti belongs functionally in this group; but it is not interosseous. *Situation,* one in each metacarpal interspace near the dorsal aspect. *Origin,* each from the two bones

between which it lies. *Direction*, downward. *Insertion*, each into the base of a first phalanx, and also into the extensor tendon of the same finger, the first on the radial side of the index, the second on the radial side of the medius, the third on the ulnar side of the medius, the fourth on the ulnar side of the annularis. *Action*: each abducts from a line coinciding with the long axis of the middle finger. This digit, having two interossei inserted into it, is abducted toward the radial side by one, and toward the ulnar side by the other; thus, each in turn becomes an adductor, for the finger being abducted by one is then restored to the mid-line (*i. e.*, adducted) by the other. They also flex the first phalanges and extend the second and third. *Nerve*, the deep branch of the ulnar.

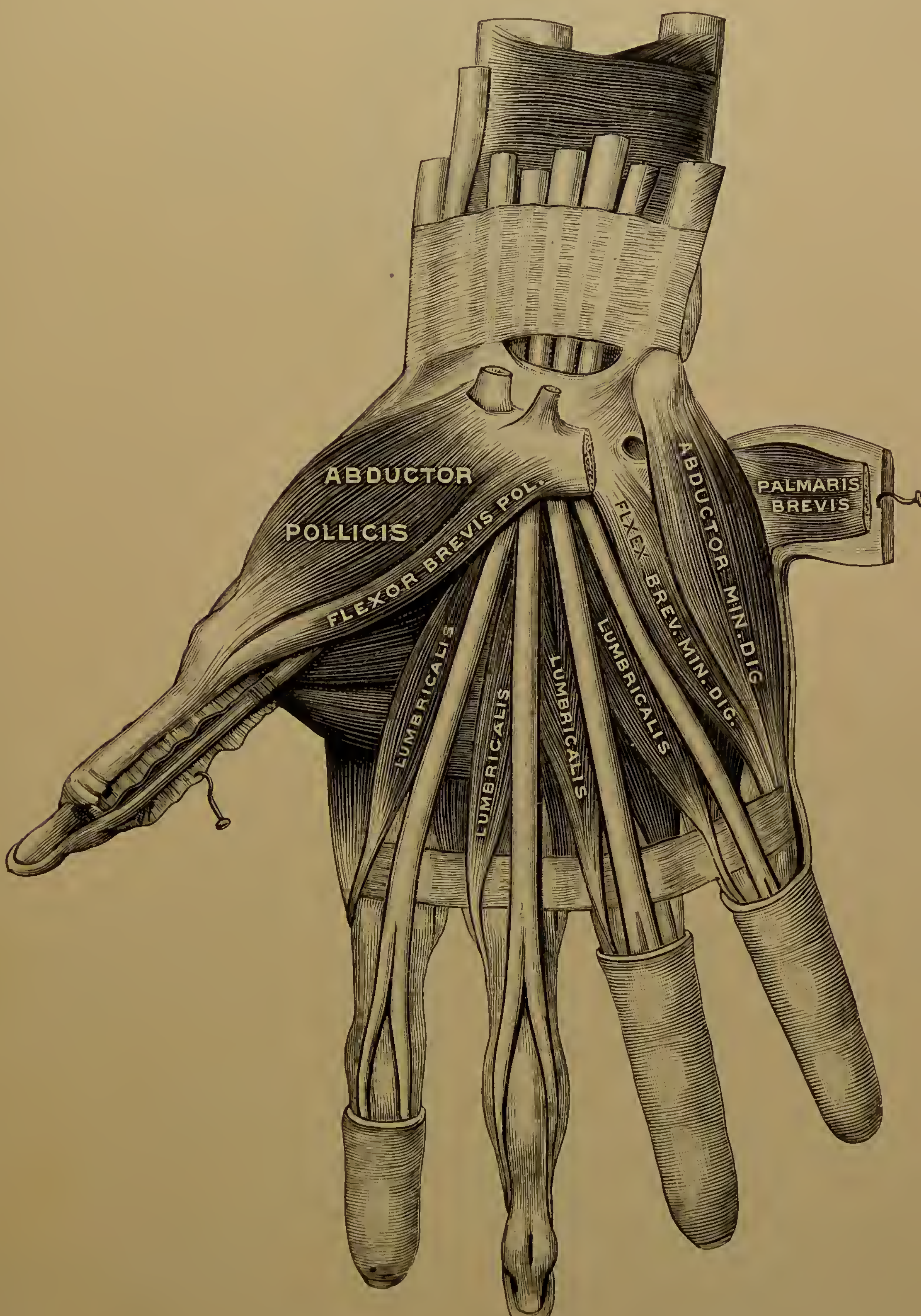

FIG. 336.—Muscles of the right palm. The palmaris brevis is reflected to the ulnar side. (Testut.)

Abductor Minimi Digiti (Fig. 336).—"The abductor of the least digit"—*i. e.*, of the little finger. *Synonym*, abductor digiti quinti, "the abductor of the fifth

digit." *Situation*, the ulnar border of the hand. *Origin*, the pisiform. *Direction*, downward. *Insertion*, the ulnar border of the base of the first phalanx of the little finger and the tendon of the extensor minimi digiti. *Action*, abduction of the little finger. *Nerve*, the deep branch of the ulnar. Its function puts it in the group with the interossei dorsales, as it draws its digit from the mid-line of the hand.

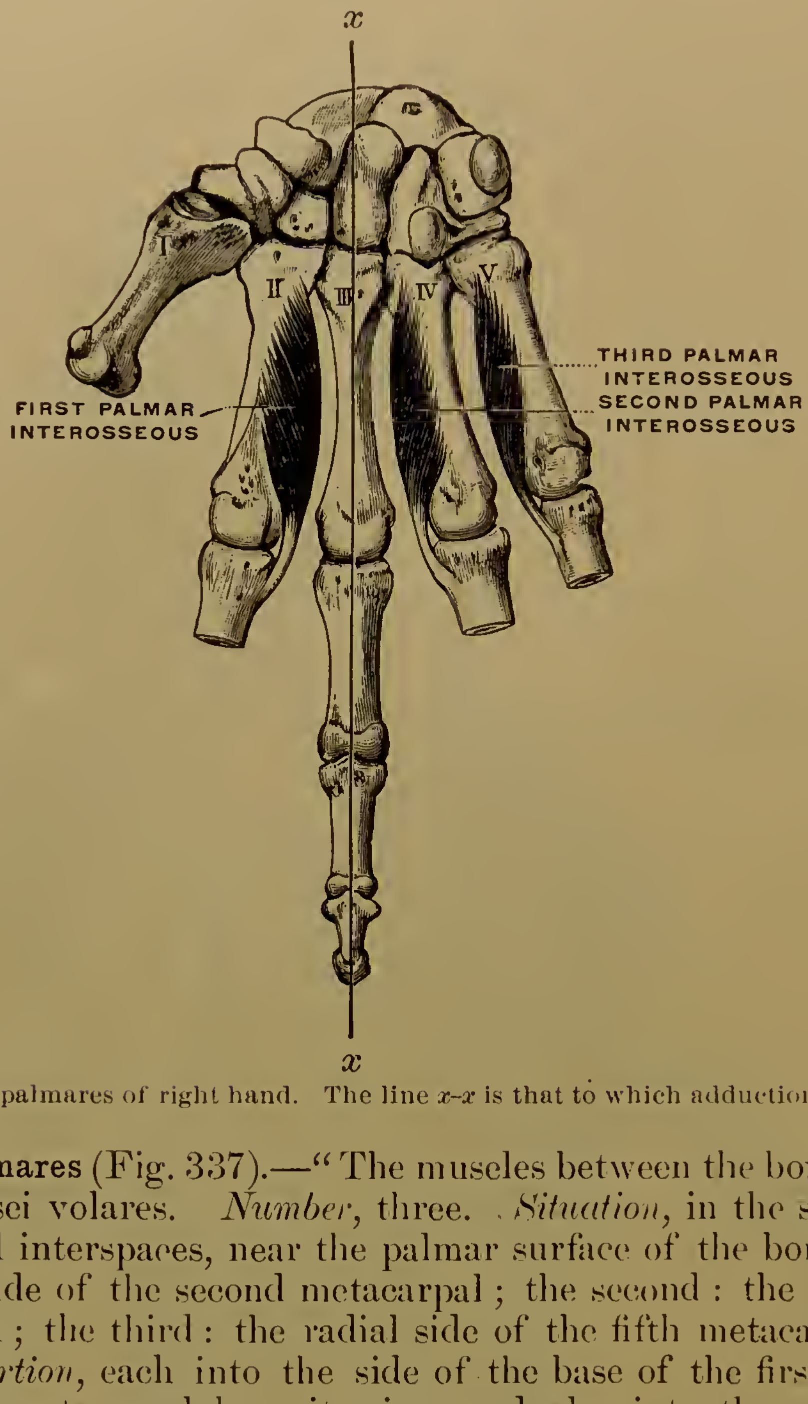

FIG. 337.—Interossei palmares of right hand. The line x–x is that to which adduction is made. (Testut.)

Interossei Palmares (Fig. 337).—"The muscles between the bones in the palm." *Synonym*, interossei volares. *Number*, three. *Situation*, in the second, third, and fourth metacarpal interspaces, near the palmar surface of the bones. *Origin*, the first: the ulnar side of the second metacarpal; the second: the radial side of the fourth metacarpal; the third: the radial side of the fifth metacarpal. *Direction*, downward. *Insertion*, each into the side of the base of the first phalanx of the digit from whose metacarpal bone it arises, and also into the corresponding extensor tendon. *Action*, each adducts its digit toward the middle finger; also, it flexes the first phalanx of its digit, and extends the second and third phalanges. *Nerve*, the deep branch of the ulnar.

MUSCLES MOVING THE THUMB

and its Metacarpal Bone.

(Those entirely in the hand are indicated by a star.)

Flexors.	*Extensors.*
*Flexor ossis metacarpi pollicis.	Extensor ossis metacarpi pollicis.
*Flexor brevis pollicis.	Extensor brevis pollicis.
Flexor longus pollicis.	Extensor longus pollicis.
Abductor.	*Adductor.*
*Abductor pollicis.	*Adductor pollicis.

The movements of the first metacarpal bone are so closely associated with those of the phalanges which it carries, that it is profitable to consider its special muscles in the group with those of the thumb. The longer name of the metacarpal flexor is preferred as indicating its action as well as "opponens pollicis," and at the same time expressing much more clearly the antagonism between it and the metacarpal extensor.

Flexor Ossis Metacarpi Pollicis (Figs. 338, 329).—"The flexor of the metacarpal bone of the thumb." *Synonym,* opponens pollicis, "the opponent muscle of the thumb"—referring to its action in opposing the thenar eminence to the hypothenar, so that the palmar hollow is deepened and narrowed, and a body

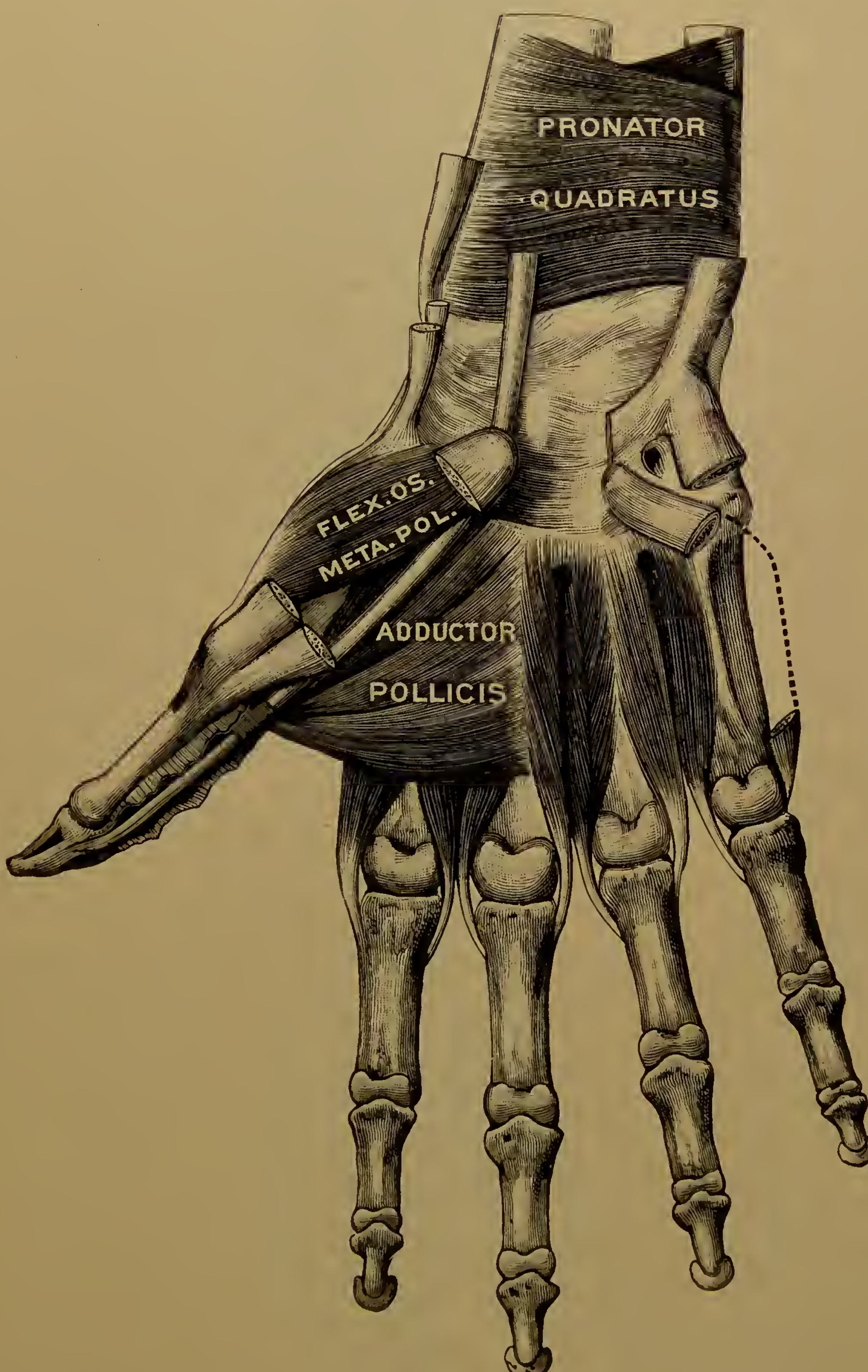

Fig. 338.—Adductor pollicis, flexor ossis metacarpi pollicis, and pronator quadratus. (Testut.)

between these muscular mounds can be grasped by them. *Situation,* deep in the thenar eminence. *Origin,* the palmar aspect of the trapezium and annular ligament. *Direction,* downward and outward. *Insertion,* the whole shaft of the

metacarpal bone of the thumb on its radial side and anterior aspect. *Action*, flexion and inward rotation of the first metacarpal bone. *Nerve*, the median.

Flexor Brevis Pollicis (Fig. 329).—"The short flexor of the thumb." *Situation*, deep in the thenar eminence. *Origin*, the outer (superficial) head: the trapezium and the outer two-thirds of the annular ligament; the inner (deep) head: the proximal part of the first metacarpal on the ulnar side. *Direction*, downward and outward. *Insertion*, the outer head: the outer side of the base of the first phalanx of the thumb, with the abductor pollicis; the inner head: the inner side of the same, with the adductor pollicis. In each tendon of insertion is a sesamoid bone. *Action*, flexion of the first phalanx of the thumb. *Nerves*, outer head: the median; inner head: the ulnar.

Fig. 339.—Flexor longus pollicis of right side: outline and attachment-areas. (F. H. G.)

Flexor Longus Pollicis (Figs. 326, 339).—"The long flexor of the thumb." *Situation*, deep in the front part of the forearm, and on the palmar aspect of the thumb. *Origin*, the anterior surface of the radius from the oblique line to the upper line of the pronator quadratus, the adjacent part of the interosseous membrane, and sometimes the base of the coronoid process of the ulna. *Direction*, downward to the wrist, then downward and outward, the tendon passing between the two points of insertion of the flexor brevis pollicis. *Insertion*, the front of the base of the last phalanx of the thumb. *Action*, flexion of the last phalanx of the thumb. *Nerve*, the anterior interosseous branch of the median.

Extensor Ossis Metacarpi Pollicis (Figs. 340, 341).—"The extensor of the metacarpal bone of the thumb." *Synonym*, abductor longus pollicis, "the long abductor of the thumb." *Situation*, deep in the lower two-thirds of the back of the forearm and in the radial side of the wrist. *Origin*, small areas below the attachments of the supinator on both radius and ulna, and the interosseous membrane between these surfaces. *Direction*, downward and outward. *Insertion*, the base of the metacarpal bone of the thumb. *Action*, extension and abduction of the metacarpal bone of the thumb. *Nerve*. the posterior interosseous branch of the musculo-spiral.

Extensor Brevis Pollicis (Figs. 340, 342).—"The short extensor of the thumb." *Synonym*, extensor primi internodii pollicis, "the extensor of the first phalanx of the thumb." *Situation*, deep in the lower half of the back of the forearm on the outer side, and in the metacarpus. *Origin*, a small area of the radius, just below the extensor ossis metacarpi pollicis, and the adjacent portion of the interosseous membrane. *Direction*, downward and outward. *Insertion*, the back of the base of the first phalanx of the thumb. *Action*, extension of the thumb. *Nerve*, the posterior interosseous branch of the musculo-spiral.

Extensor Longus Pollicis (Figs. 340, 343).—"The long extensor of the thumb." *Synonym*, extensor secundi internodii pollicis, "the extensor of the second phalanx of the thumb." *Situation*, deep in the lower half of the back of forearm and in

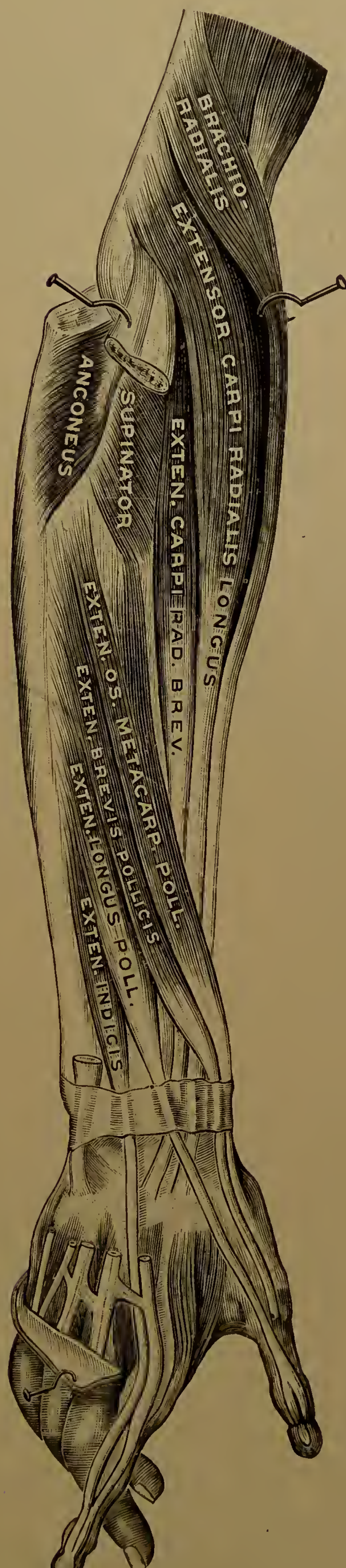

FIG. 340.—Muscles in radial region of right forearm, and deep muscles in its dorsum. (Testut.)

the thumb. *Origin,* the middle third of the dorsal surface of the ulna, below the extensor ossis metacarpi pollicis, and the neighboring part of the interosseous membrane. *Direction,* downward and outward. *Insertion,* the back of the base of the last phalanx of the thumb. *Action,* extension of the last phalanx of the thumb. *Nerve,* the posterior interosseous branch of the musculo-spiral.

Abductor Pollicis (Fig. 336).—"The abductor of the thumb." *Synonym,* abductor pollicis brevis, "the short abductor of the thumb." *Situation,* superficial, on the radial side of the metacarpal bone of the thumb. *Origin,* the front of the annular ligament, and, to a slight extent, the trapezium and scaphoid. *Direction,* downward and outward. *Insertion,* the base of the first phalanx of the thumb on the outer side, in common with the outer insertion of the flexor brevis pollicis. *Action,* abduction of thumb. *Nerve,* the median.

FIG. 341.—Extensor ossis metacarpi pollicis of right side: outline and attachment-areas. (F. H. G.)

FIG. 342.—Extensor brevis pollicis of right side: outline and attachment-areas. (F. H. G.)

FIG. 343.—Extensor longus pollicis of right side: outline and attachment-areas. (F. H. G.)

Adductor Pollicis (Fig. 338).—"The adductor of the thumb." *Situation,* deep in the outer half the palm. *Origin,* one head: the os magnum, the bases of the second and third metacarpals, and the annular ligament; the other head: the lower two-thirds of the third metacarpal. *Direction,* the upper part: downward

and outward; the lower part: outward. *Insertion*, the inner side of the base of the first phalanx of the thumb, in common with the inner insertion of the flexor brevis pollicis. *Action*, adduction and flexion of the thumb. *Nerve*, the ulnar. The upper portion of this muscle is often described as *adductor obliquus pollicis*, and the lower as *adductor transversus pollicis*.

The interossei, the abductor and adductor pollicis, and the abductor minimi digiti may well be considered together as constituting a distinct physiological group, the members of which are concerned either in abduction or adduction, or both (Fig. 344). Each of the five digits has attached to the base of its first

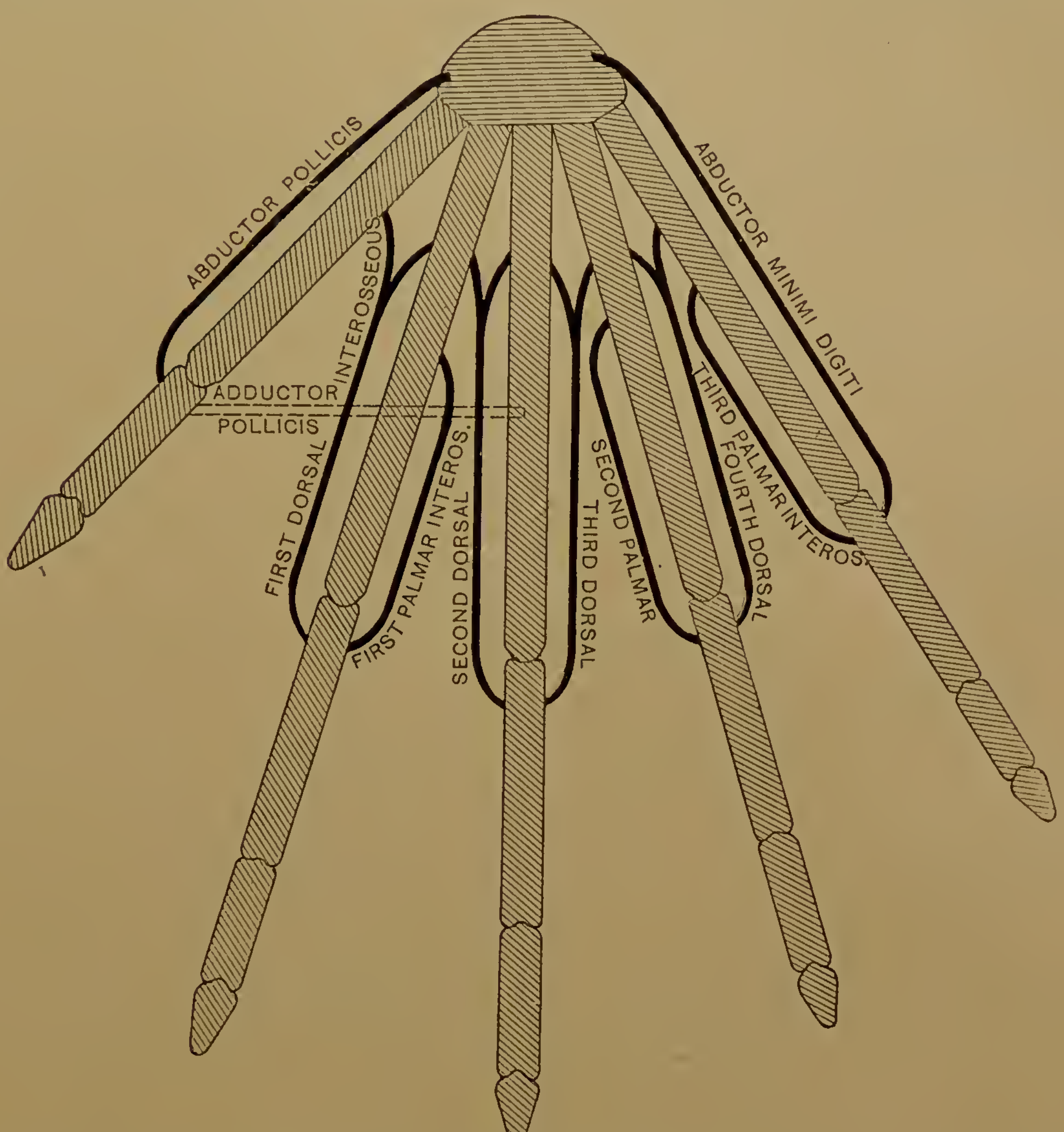

FIG. 344.—Diagram showing the arrangement of the adductors and abductors of the digits of the hand. (F. H. G.)

phalanx two of these ten muscles, one upon the radial, the other upon the ulnar side. The thumb has the *abductor* and *adductor pollicis*; the forefinger has the *first dorsal interosseous* (abductor indicis) and the *first palmar interosseous* (the adductor of the index); the ring finger has the *second palmar interosseous* (the adductor of the annularis) and the *fourth dorsal interosseous* (the abductor of the annularis); the little finger has the *third palmar interosseous* (the adductor of the least digit) and the *abductor minimi digiti*. The lateral opponent muscles of the middle finger are the *second* and *third dorsal interosseous*—the one drawing the digit from the middle line toward the radial side, the other drawing it from the middle line toward the ulnar side—that is, both are abductors. But, the finger being displaced laterally by one of these muscles, is restored to the middle line by the action of the other; and thus it is seen that the second and third dorsal interosseous are, on occasion, adductors as well as abductors.

One other muscle must be described, although it is so diminutive and nearly powerless that it does not deserve a place in any of the specified groups.

Palmaris Brevis (Fig. 336.)—"The short palmar muscle." *Situation*, subcutaneous at the proximal part of the palm. *Origin*, the inner border of the palmar fascia and the middle

of the annular ligament. *Direction*, inward. *Insertion*, the skin at the inner border of the palm. *Action*, wrinkling the skin of the hypothenar eminence and slightly deepening the hollow of the palm. *Nerve*, the ulnar.

Although the classification of the muscles of the upper limb which has been given is regarded as the most helpful to the learner and to the practitioner, it is desirable that they should be studied from other points of view also; and, therefore, a regional classification is herewith presented, based upon the situation of the main portion of each of these structures.

Muscles which Move the Upper Limb, Grouped according to their Location.

In the Superficial Layer of the Back of the Trunk.

Trapezius. Latissimus.

In the Second Layer of the Back of the Trunk.

Levator scapulæ. Rhomboideus minor.
Rhomboideus major.

On the Front of the Chest.

Pectoralis major. Pectoralis minor.
Subclavius.

On the Side of the Chest.

Serratus magnus.

In the Back Part of the Shoulder.

Supraspinatus. Infraspinatus.
Teres major. Teres minor.
Subscapularis.

In the Outer Part of the Shoulder.

Deltoideus.

In the Inner Side of the Arm.

Coraco-brachialis.

In the Front Part of the Arm.

Biceps flexor cubiti. Brachialis.

In the Back Part of the Arm.

Triceps extensor cubiti.

In the Front Part of the Forearm.

Pronator teres. Flexor carpi radialis.
[Flexor] palmaris longus. Flexor carpi ulnaris.
Flexor sublimis digitorum. Flexor profundus digitorum.
Flexor longus pollicis. Pronator quadratus.

In the Outer Part of the Forearm.

Brachio-radialis. Extensor carpi radialis longus.
Extensor carpi radialis brevis.

In the Back Part of the Forearm.

Anconeus.
Extensor communis digitorum.
Extensor minimi digiti.
Extensor carpi ulnaris.
Extensor ossis metacarpi pollicis.
Extensor brevis pollicis.
Extensor longus pollicis.
Extensor indicis.
Supinator.

In the Thenar Eminence.

Abductor pollicis.
Flexor ossis metacarpi pollicis.
Flexor brevis pollicis.
Adductor pollicis.

In the Hypothenar Eminence.

Abductor minimi digiti.
Flexor ossis metacarpi minimi digiti.
Flexor brevis minimi digiti.
Palmaris brevis.

In the Palm of the Hand between the Eminences.

Lumbricales.
Interossei palmares.
Interossei dorsales.

The student is advised to make other classifications of the muscles moving the limbs, in order to obtain as complete a practical knowledge of them as possible. For example, let him group the muscles *according to the parts which they connect*, under some such headings as the following :

Connecting the head, neck, and (or) trunk with the shoulder.
Connecting the trunk with the arm.
Connecting the shoulder with the arm.
Connecting the shoulder with the forearm.
Connecting the arm with the forearm.
Connecting the bones of the forearm.
Connecting the arm with the hand.
Connecting the forearm with the hand.
Connecting the parts of the hand with each other.

Again, let him enumerate the muscles which would be *cut by plane sections made transversely through the limb* at different levels, as, for example, at the middle of the arm, in the lower third of the arm, in the upper quarter of the forearm, and so on. The more ways he adopts for considering the subject, the more exact, permanent, and usable will be his knowledge.

THE MUSCLES OF THE LOWER LIMB.

In making a physiological classification of the muscles of the lower limb, we notice at the outset that there is a great difference between the mobility of the first segment of the upper limb and that of its homologue in the lower: the shoulder is freely movable, the hip is almost immovably fixed. There is no group of muscles devoted to moving the pelvic girdle at all comparable with those concerned in the movements of the shoulder. The great muscles of the abdominal wall lift the front of the pelvis; but this is accompanied to no appreciable extent by movement of the hip-bones at their articulations with the sacrum, but by the curving of the vertebral column. The very inconstant psoas parvus is sometimes asserted to flex the pelvis; but this may well be questioned,

and the muscle, which is frequently absent, probably has no effect except in tightening the iliac fascia. No group of muscles, therefore, will be presented as acting upon the hip.

Movements of the Thigh.—The ball-and-socket joint at the hip permits movement of the thigh in every direction. That forward is called *flexion*, backward is *extension*, outward is *abduction*, inward is *adduction*. *Rotation* and *circumduction* are like the same movements in the upper extremity.

Movements of the Leg.—At the knee the joint is a hinge, and the movements of the leg are forward, which is *extension*, and backward, which is *flexion*. Between the two long bones of the leg there is no movement comparable with the pronation and supination of the radius.

Movements of the Foot.—At the ankle is another hinge with movement of the foot forward (upward), which is *flexion*, and backward (downward), which is *extension*. The lateral movements of the foot are chiefly at the astragalo-calcanean and the medio-tarsal articulations.

Movements of the Digits.—The metatarso-phalangeal and interphalangeal articulations are almost identical with their homologues in the hand, the main difference being that the first metatarsal is like all of its fellows in its practical immobility, and thus the hallux has nothing like the capacity of the pollex—there is no power of grasping in the sole as there is in the palm. Motion of the toes forward (upward) is *extension*, in the opposite direction is *flexion*. Thus, we see that the series of forward movements presents alternately flexion and extension—of the thigh flexion, of the leg extension, of the foot flexion, of the toes extension; and the backward movements are alternately, beginning with the thigh, extension and flexion. In the upper extremity the forward movements, it will be remembered, are all flexion. The movements of the toes sidewise are *abduction* and *adduction* with reference to a line running through the normal long axis of the second digit of the foot, and not the third, as it is in the hand.

Classification of the Muscles of the Lower Limb on the Basis of their Principal Action.

Moving the Thigh.

Flexors.

Psoas magnus.
Iliacus.

Extensor.

Gluteus maximus.

Abductors.

Tensor vaginæ femoris.
Gluteus medius.
Gluteus minimus.

Adductors.

Adductor magnus.
Adductor longus.
Adductor brevis.
Adductor gracilis.
Pectineus.

Internal Rotators.

(The same as the abductors.)

External Rotators.

Obturator externus.
Quadratus femoris.
Pyriformis.
Gemellus superior.
Obturator internus.
Gemellus inferior.

Moving the Leg.

Flexors.	*Extensor.*
Sartorius.	Quadriceps extensor cruris, comprising:
Biceps flexor cruris.	Rectus femoris.
Semitendinosus.	Vastus externus.
Semimembranosus.	Vastus internus.
Popliteus.	Vastus intermedius.

Moving the Foot.

Flexors.	*Extensors.*
Tibialis anterior.	Tibialis posterior.
	Gastrocnemius.
	Soleus.
	Plantaris.
	Peroneus longus.
Peroneus tertius.	Peroneus brevis.

Moving the Digits of the Foot.

(Those situated entirely in the foot are indicated by a star.)

Flexors.	*Extensors.*
Flexor longus hallucis.	Extensor proprius hallucis.
*Flexor brevis hallucis.	
Flexor longus digitorum.	Extensor longus digitorum.
*Flexor accessorius.	
*Flexor brevis digitorum.	*Extensor brevis digitorum.
*Flexor brevis minimi digiti.	
*Lumbricales.	

Abductors.	*Adductors.*
*Abductor hallucis.	*Adductor obliquus hallucis.
*Abductor minimi digiti.	*Adductor transversus hallucis.
*Interossei dorsales.	*Interossei plantares.

MUSCLES MOVING THE THIGH.

Flexors.	*Extensor.*
Psoas magnus.	Gluteus maximus.
Iliacus.	

Abductors and Internal Rotators.	*Adductors.*
Tensor vaginæ femoris.	Adductor magnus.
Gluteus medius.	Adductor longus.
Gluteus minimus.	Adductor brevis.
	Adductor gracilis.
	Pectineus.

External Rotators.

Obturator externus.	Gemellus superior.
Quadratus femoris.	Obturator internus.
Pyriformis.	Gemellus inferior.

The *flexors of the thigh* arise partly from the lumbar vertebræ, partly from the inner surface of the false pelvis, and are inserted upon the small trochanter.

The *great extensor* arises from the back part of the hip-bone, sacrum, and coccyx, and is inserted into the gluteal ridge and the fascia lata.

The *abductors*, which are also *internal rotators*, arise from the outer aspect of the hip-bone, and are inserted two into the great trochanter and one into the neighboring fascia lata.

The *adductors* arise from the hip-bone near the middle line of the body, and four of the five pass outward and downward with varying degrees of obliquity to their insertion into the back part of the shaft of the femur, the fifth one going below the knee-joint to the upper part of the tibial shaft. They are to a considerable extent external rotators.

The *external rotators* arise partly from the inside and partly from the outside of the bony pelvis, and are all inserted about the upper end of the femur.

Psoas Magnus (Figs. 345, 346).—"The great loin muscle." *Synonym*, psoas major. *Situation*, in the hind wall of the abdomen and the upper part of the thigh.

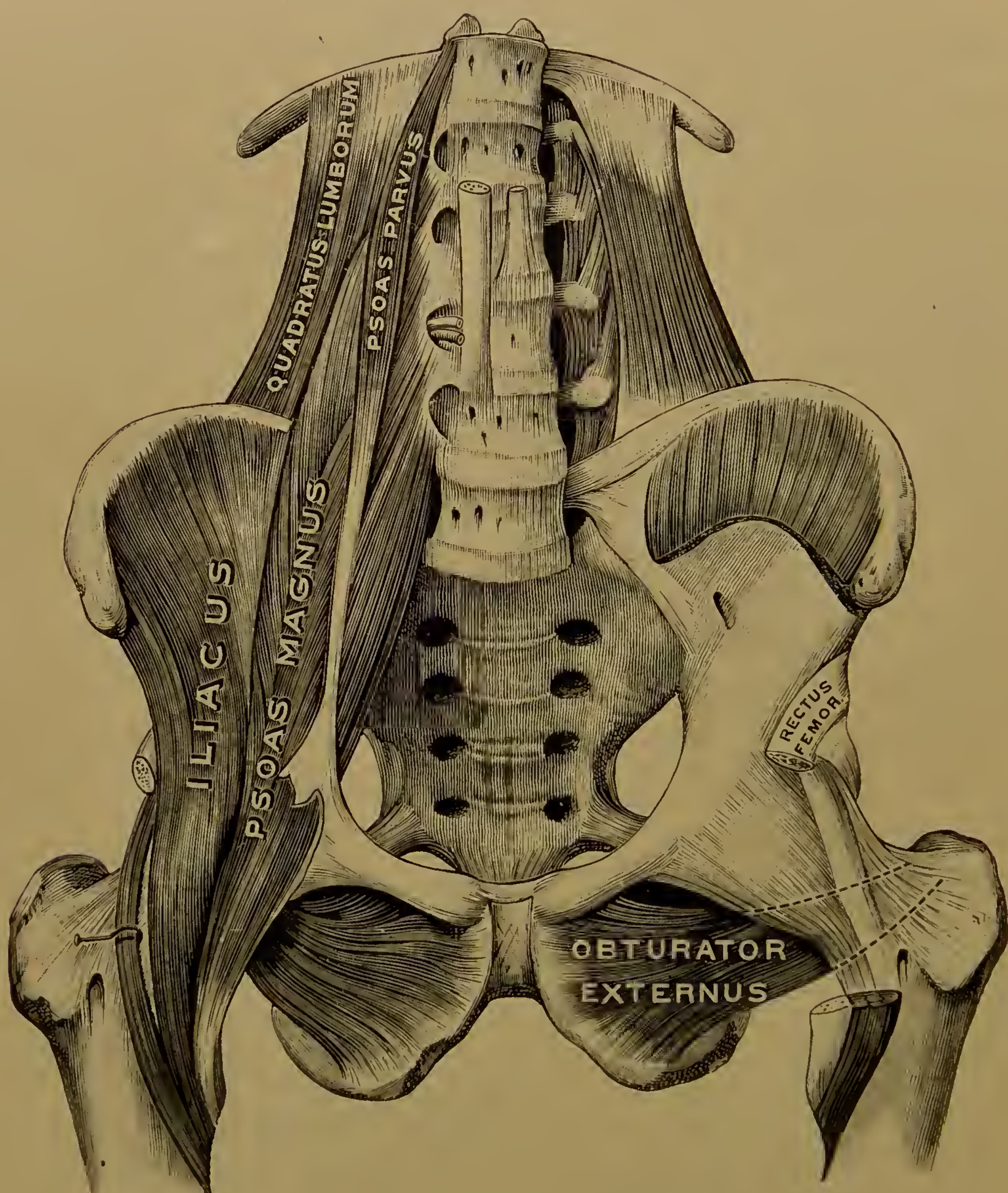

FIG. 345.—Psoas, iliacus, and obturator externus muscles. (Testut.)

Origin, the front of the transverse processes and the side of the bodies of lumbar vertebræ and the side of the body of the last thoracic, with the included intervertebral cartilages. *Direction*, down- and forward, and finally down- and back-

ward. *Insertion,* the small trochanter of the femur. *Action,* flexion and external rotation of the thigh. *Nerves,* the second and third lumbar.

Iliacus (Figs. 345, 347).—"The iliac muscle." *Synonym,* iliacus internus, "the internal iliac muscle." *Situation,* in the iliac fossa and the upper part of the thigh. *Origin,* the upper two-thirds of the iliac fossa and the ala of the

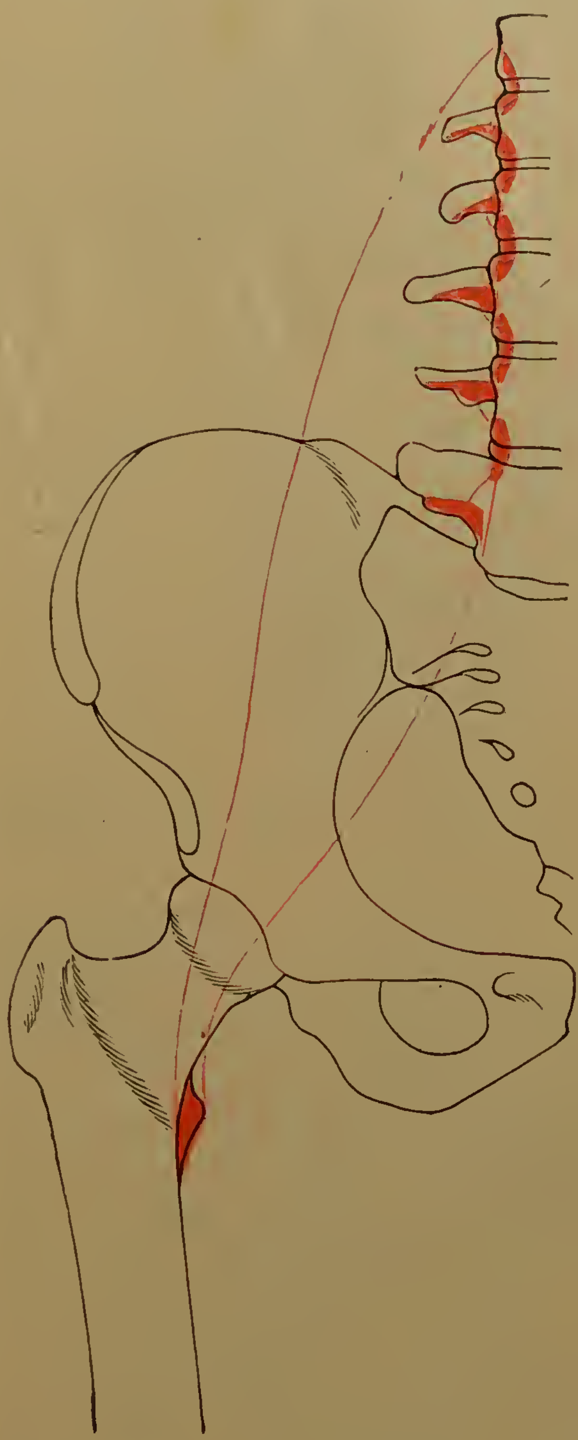

FIG. 346.—Psoas magnus of right side: outline and attachment-areas. (F. H. G.)

FIG. 347.—Iliacus of right side: outline and attachment-areas. (F. H. G.)

sacrum. *Direction,* down- and outward. *Insertion,* the tendon of the psoas magnus, the front of the small trochanter and the small surface below it. *Action,* flexion and external rotation of the thigh. *Nerve,* the anterior crural.

The two preceding muscles—psoas and iliacus—are sometimes treated as one muscle, called *ilio-psoas.*

Gluteus Maximus (Figs. 348, 349).—"The largest muscle of the buttock." *Situation,* subcutaneous in the back of the hip and upper part of the thigh. *Origin,* the hind fourth of the iliac crest, the outer surface of the ilium between the crest and the superior gluteal line, the hind surface of the lower two segments of the sacrum and upper three of the coccyx, the great sacro-sciatic ligament, and the aponeurosis of the erector spinæ. *Direction,* down- and outward. *Insertion,* the lower half to the gluteal ridge of the femur, the upper to the fascia lata. *Action,* extension and external rotation of the thigh. *Nerve,* the inferior gluteal.

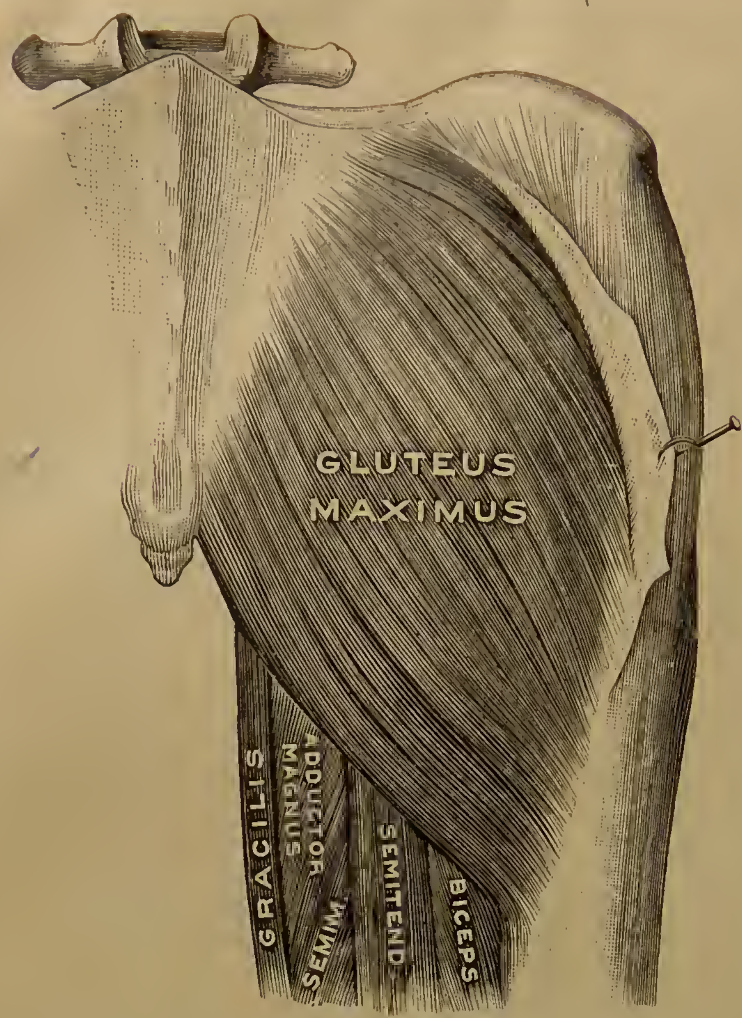

FIG. 348.—Gluteus maximus of right side. (Testut.)

FIG. 349.—Gluteus maximus of right side: outline and attachment-areas. (F. H. G.)

Tensor Vaginæ Femoris (Figs. 350, 368).—"The tightener of the sheath of the thigh." *Synonym*, tensor fasciæ latæ, "the tightener of the broad fascia." *Situation*, in the front part of the outer aspect of the hip and thigh. *Origin*, the outer surface of the front part of the crest of the ilium. *Direction*, downward and slightly backward. *Insertion*, the fascia lata several inches below the great trochanter. *Action*, tightening of the fascia lata, abduction and inward rotation of thigh. *Nerve*, the superior gluteal.

FIG. 350.—Tensor vaginæ femoris of right side: outline and attachment-areas. (F. H. G.)

Gluteus Medius (Figs. 351, 352).—"The middle buttock-muscle." *Situation*, in the outer part of the hip from the iliac crest to the trochanter major. *Origin*, the external surface of the ilium between the crest and the superior and middle gluteal lines. *Direction*, downward. *Insertion*, the outer surface of the trochanter major. *Action*, abduction of the thigh, and, when the thigh is flexed, inward rotation. *Nerve*, the superior gluteal.

Gluteus Minimus (Figs. 353, 354).—"The smallest buttock-muscle." *Situation*, in the outer part of the hip, from the front part of the crest to the great trochanter. *Origin*, the external surface of the ilium, between the middle and

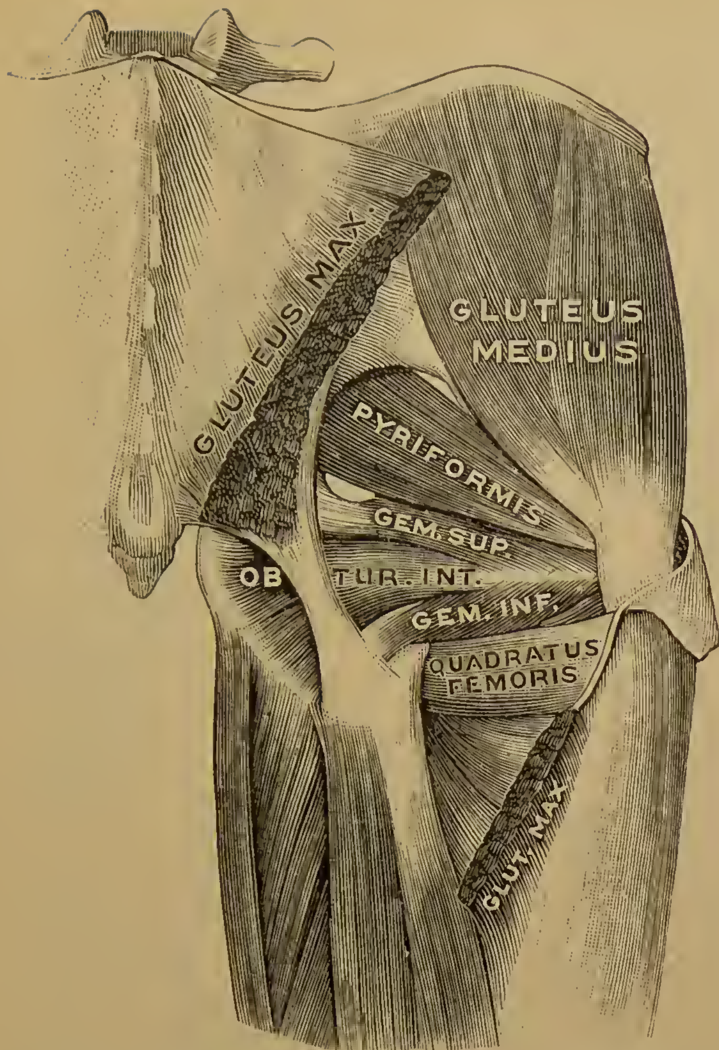

FIG. 351.—Muscles of right hip, viewed from behind, the gluteus maximus having been cut away. (Testut.)

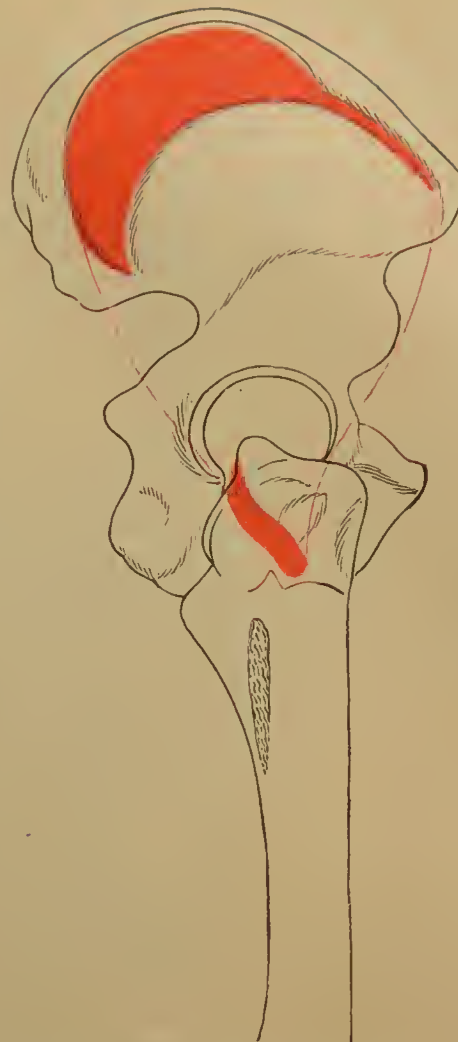

FIG. 352.—Gluteus medius of right side: outline and attachment-areas. (F. H. G.)

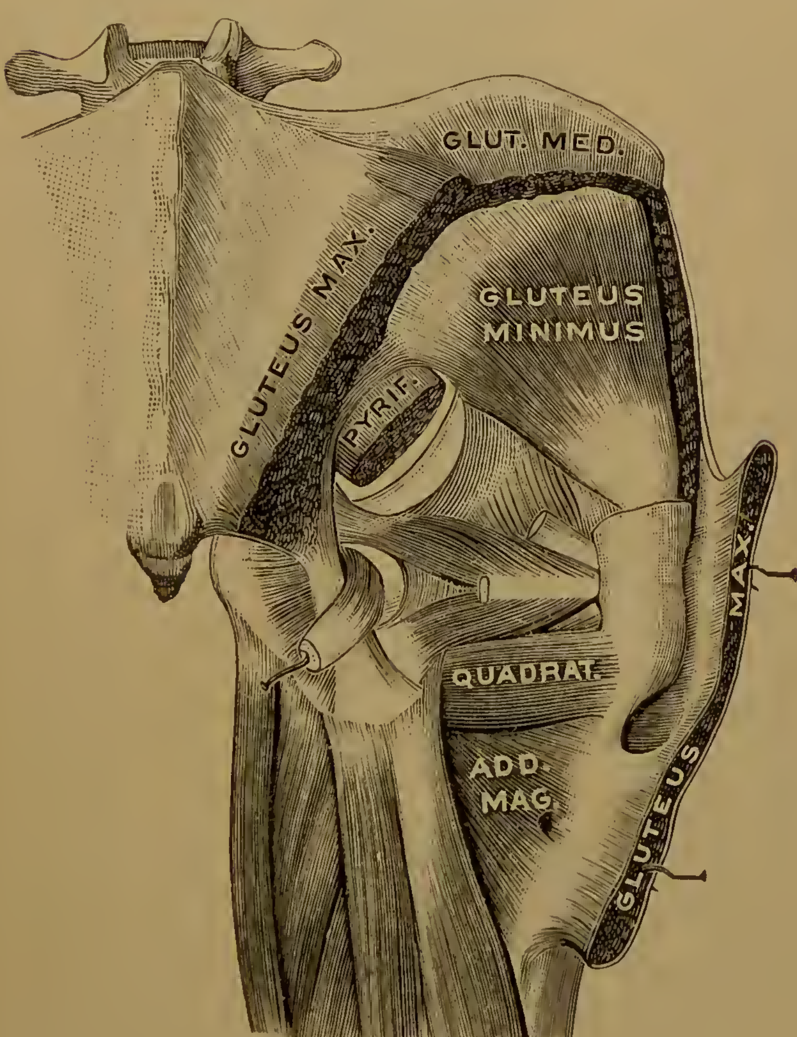

FIG. 353.—Gluteus minimus of right side. (Testut.)

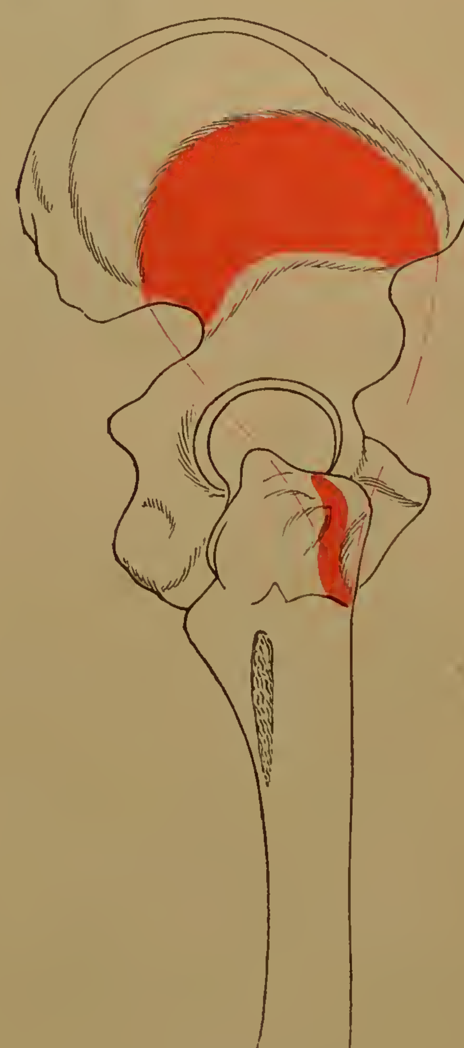

FIG. 354.—Gluteus minimus of right side: outline and attachment-areas. (F. H. G.)

inferior gluteal lines. *Direction*, down- and outward. *Insertion*, the front of the great trochanter. *Action*, abduction of the thigh, when it is extended; inward rotation, when it is flexed. *Nerve*, the superior gluteal.

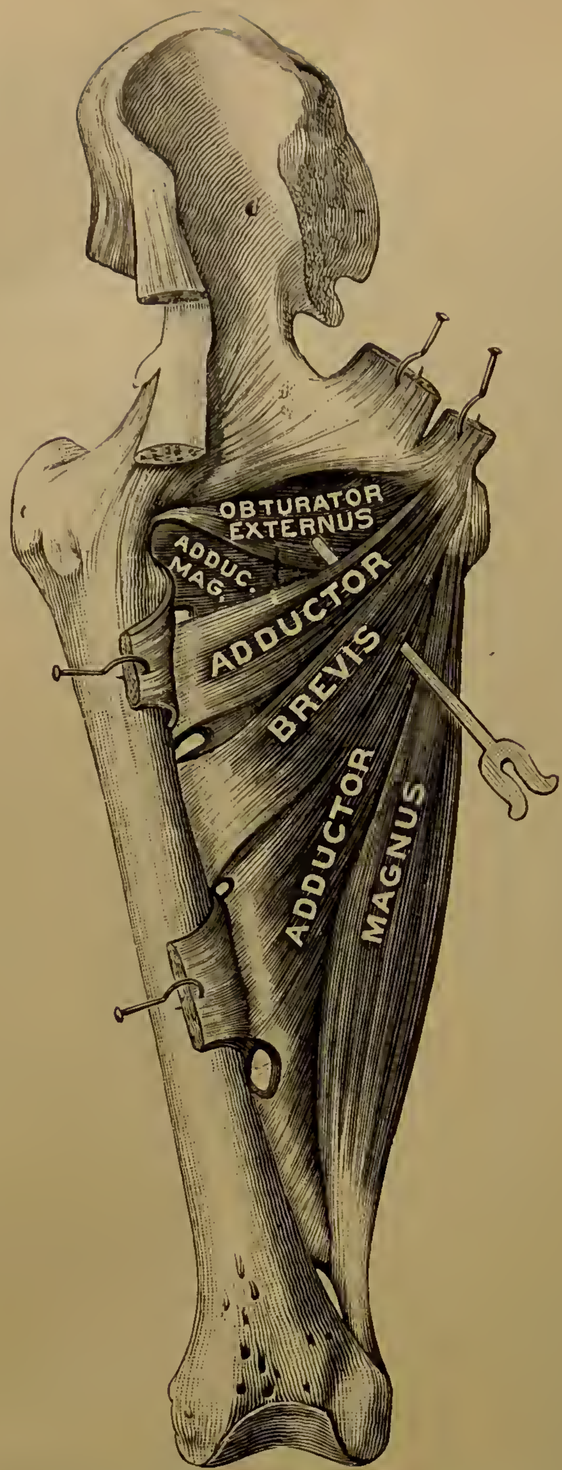

FIG. 355.—Adductores magnus and brevis of right side. (Testut.)

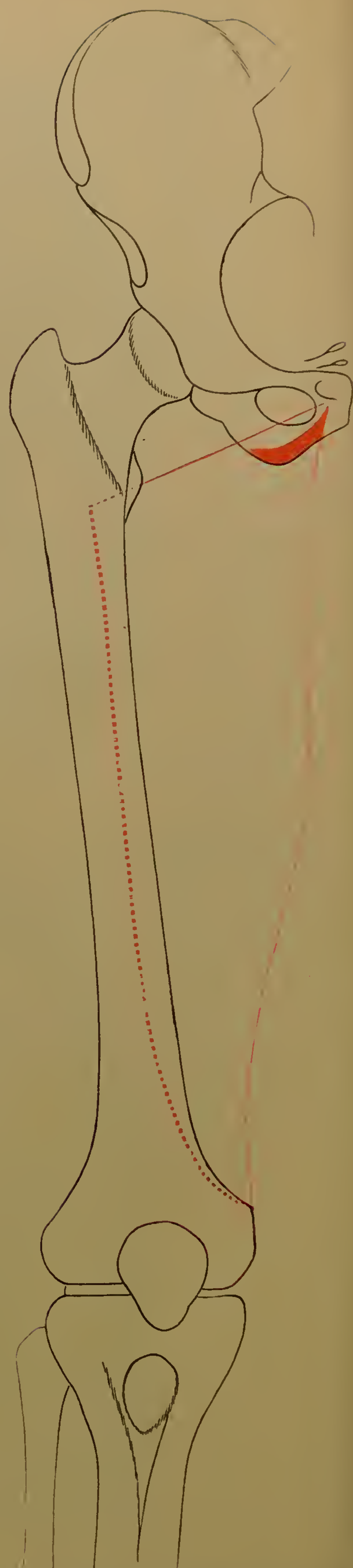

FIG. 356.—Adductor magnus of right side: outline and attachment-areas. (F. H. G.)

Adductor Magnus (Figs. 355, 356, 373).—"The great adductor." *Situation,* in the inner side of the thigh. *Origin,* the ramus of the os pubis, the ramus and tuberosity of the ischium. *Direction,* from the ischial tuberosity downward; from the pubic body outward, from the intermediate parts obliquely downward and outward. *Insertion,* the gluteal ridge, the inner lip of the linea aspera, the internal condylar ridge and the adductor tubercle. The femoral attachment is broken by several arches. *Action,* adduction and external rotation of the thigh. The part from the ischial tuberosity is extensor. *Nerves,* the obturator and the great sciatic.

Adductor Longus (Figs. 357, 358).—"The long adductor." *Situation,* in the inner side of the thigh. *Origin,* the body of the os pubis near the angle. *Direction,* down-, out-, and backward. *Insertion,* the inner lip of the linea aspera about the middle third

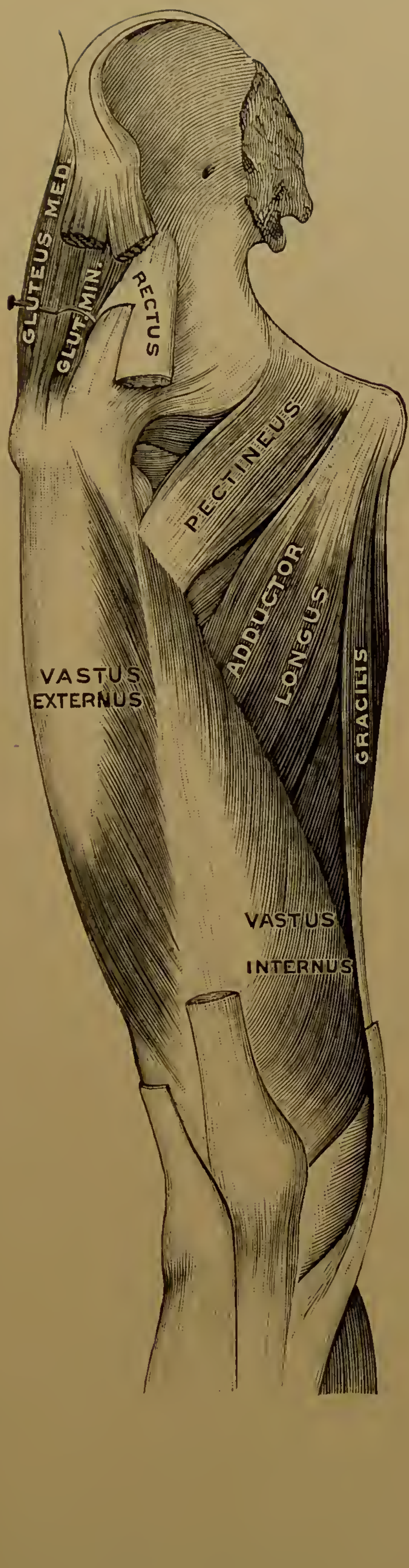

FIG. 357.—Muscles in the right thigh, viewed from in front, after removal of the rectus and sartorius. (Testut.)

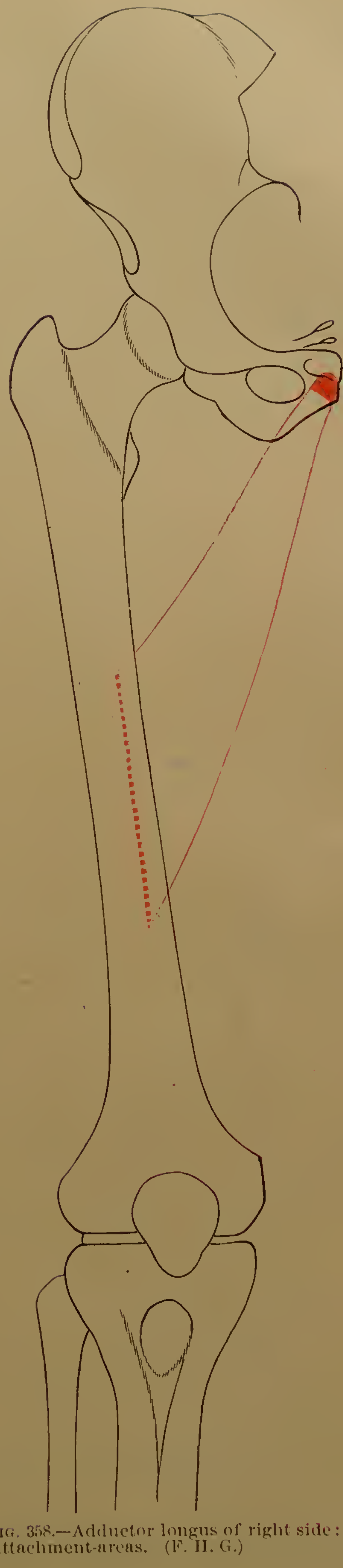

FIG. 358.—Adductor longus of right side: outline and attachment-areas. (F. H. G.)

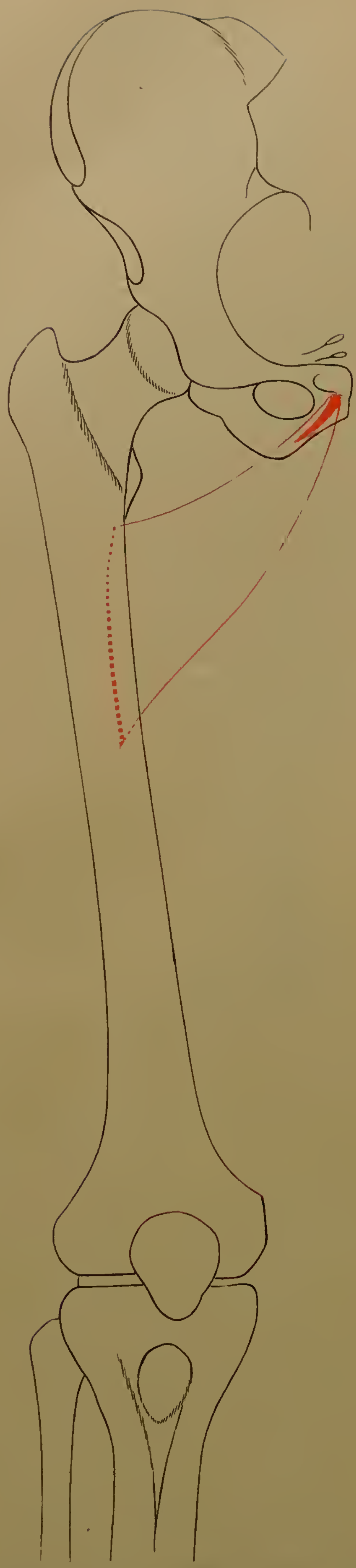

FIG. 359.—Adductor brevis of right side: outline and attachment-areas. (F. H. G.)

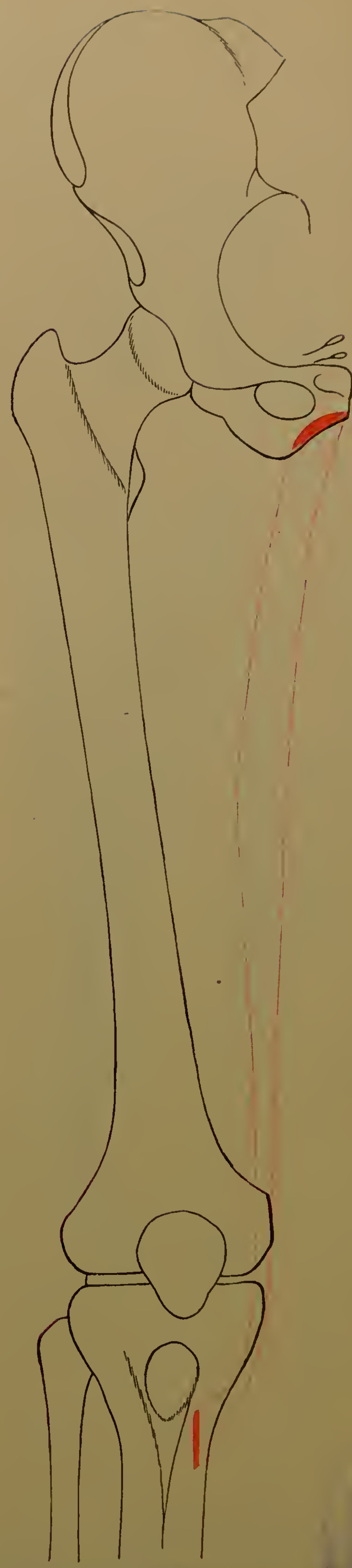

FIG. 360.—Adductor gracilis of right side: outline and attachment-areas. (F. H. G.)

of the thigh. *Action,* adduction, flexion, and external rotation of the thigh. *Nerve,* the obturator.

Adductor Brevis (Figs. 355, 359).—"The short adductor." *Situation,* in the inner and upper part of the thigh. *Origin,* the outer surface of the body and descending ramus of the os pubis. *Direction,* down-, out-, and backward. *Insertion,* the line from the small trochanter to the linea aspera and the upper part of the linea aspera. *Action,* adduction, flexion, and external rotation of the thigh. *Nerve,* the obturator.

Adductor Gracilis (Figs. 357, 360, 372).—"The slender adductor." *Situation,* in the inner side of the thigh near the surface. *Origin,* the inner margin of the os pubis, the lower half of the symphysis, and the whole length of the inferior ramus. *Direction,* downward, behind the inner condyle of the femur, and, below the knee, forward. *Insertion,* the upper part of the inner surface of the tibia. *Action,* adduction of the thigh; also, flexion and inward rotation of the leg. *Nerve,* the obturator.

Pectineus (Figs. 357, 361).—"The pubic muscle." *Situation,* between the pubic bone and the upper, back part of the thigh. *Origin,* the ileo-pectineal line

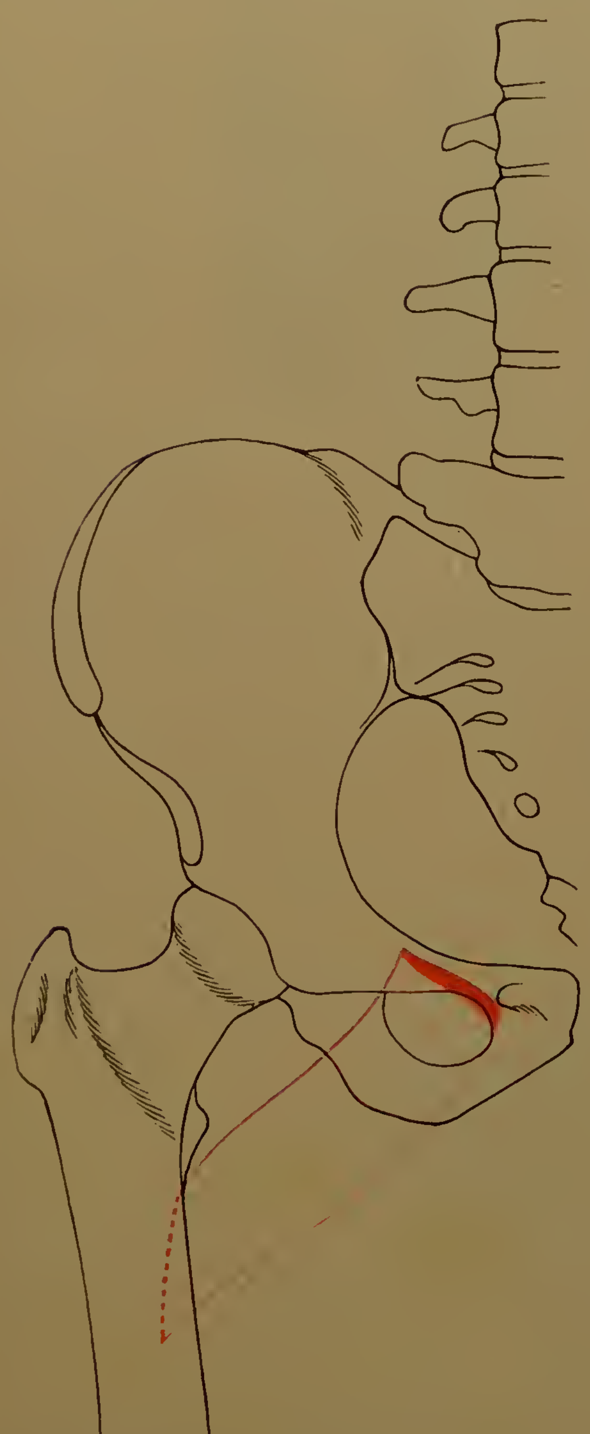

Fig. 361.—Pectineus of right side: outline and attachment-areas. (F. H. G.)

Fig. 362.—Obturator externus of right side: outline and attachment-areas. (F. H. G.)

and the surface in front of it. *Direction,* down-, out-, and backward. *Insertion,* the rough line from the small trochanter to the linea aspera. *Action,* adduction,

flexion, and outward rotation of the thigh. *Nerves,* the anterior crural and sometimes the obturator.

Obturator Externus (Figs. 355, 362).—"The outer obturator muscle," so called from its origin. *Situation,* between the obturator region on the outer surface of the pelvis and the digital fossa of the femur, behind and beneath the hip-joint. *Origin,* the inner half of the outer surface of the obturator membrane, the adjoining surfaces of the pubic body, and the pubic and ischial rami. *Direction,* outward, then backward and upward, close to the under and hind surfaces of the cervix femoris. *Insertion,* the bottom of the digital fossa. *Action,* outward rotation and adduction of the thigh. *Nerve,* the obturator.

Quadratus Femoris (Figs. 351, 353, 363).—"The square muscle of the thigh." *Situation,* between the tuber ischii and the upper part of the shaft of the femur.

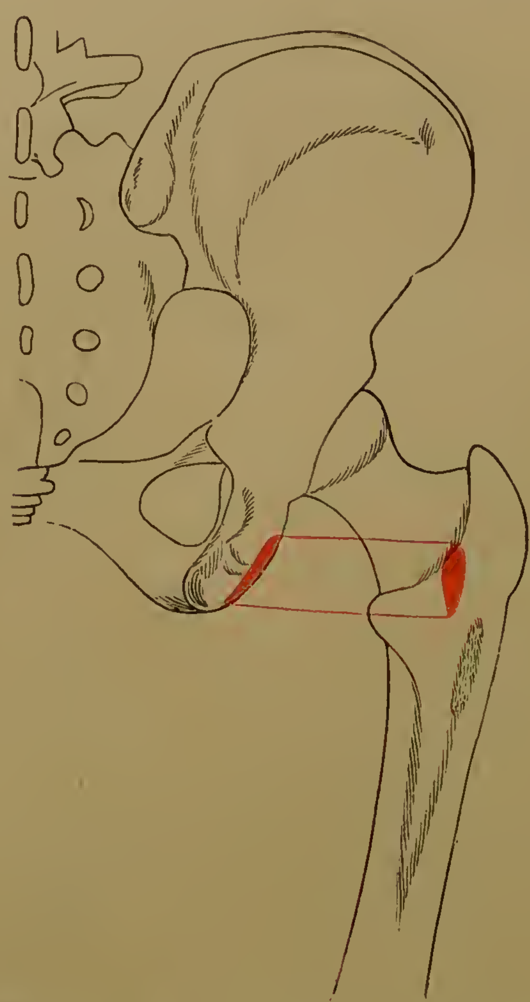

FIG. 363.—Quadratus femoris of right side; outline and attachment-areas. (F. H. G.)

Origin, the outer border of the tuberosity of the ischium. *Direction,* outward. *Insertion,* the linea quadrati. *Action,* external rotation and adduction of the thigh. *Nerve,* from the sacral plexus.

Pyriformis (Figs. 364, 365).—"The pear-shaped muscle." *Situation,* between the front of the hind wall of the true pelvis and the upper end of the thigh. *Origin,* the ventral surface of the second, third, and fourth pieces of the sacrum, between and outside of the anterior foramina, and the hind border of the ilium below the inferior spine. *Direction,* nearly horizontally outward by the great sacro-sciatic foramen. *Insertion,* the front of the upper border of the great trochanter. *Action,* when the femur is extended, external rotation; when it is flexed, abduction. *Nerve,* from the sacral plexus.

The obturator internus and the two gemelli are so intimately related that it would be rational to consider them as a single muscle; but, as they are always treated as separate organs, the conventional rule is here observed.

Gemellus Superior (Fig. 364).—"The upper little twin muscle." *Situation,* above the tendon of the obturator internus. *Origin,* the spine of the ischium. *Direction,* outward. *Insertion,* the front of the inner surface of the great tro-

chanter. *Action,* assistant to the obturator internus. *Nerve,* from the sacral plexus.

Obturator Internus (Fig. 366).—"The internal obturator muscle," referring to

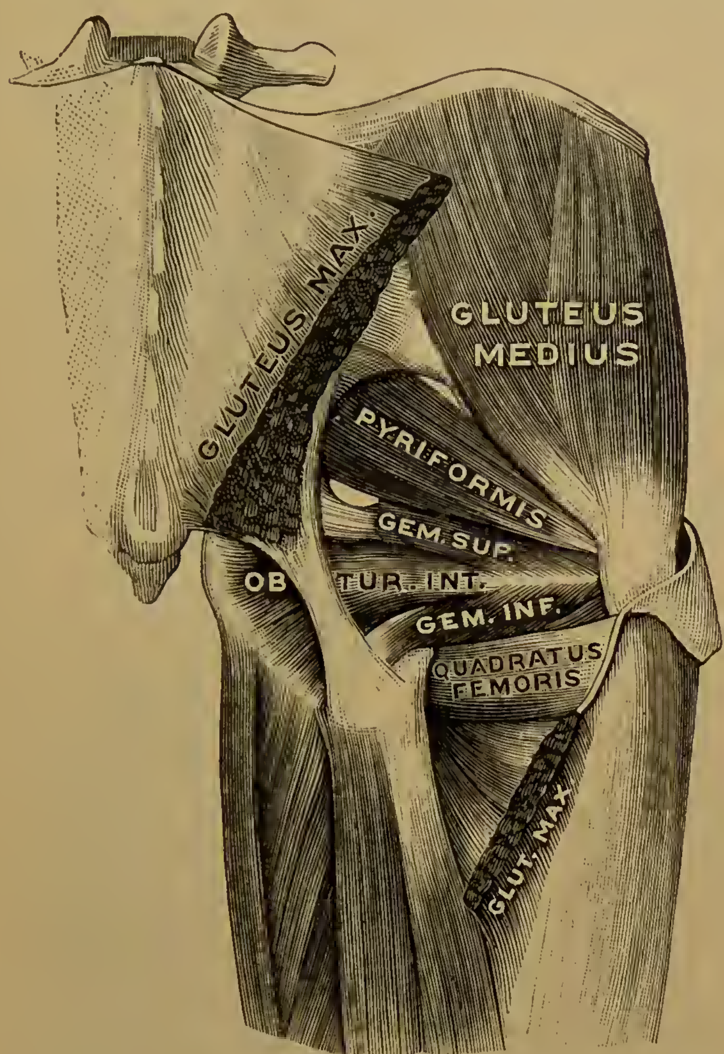

FIG. 364.—Muscles of right hip viewed from behind, the gluteus maximus having been cut away. (Testut.)

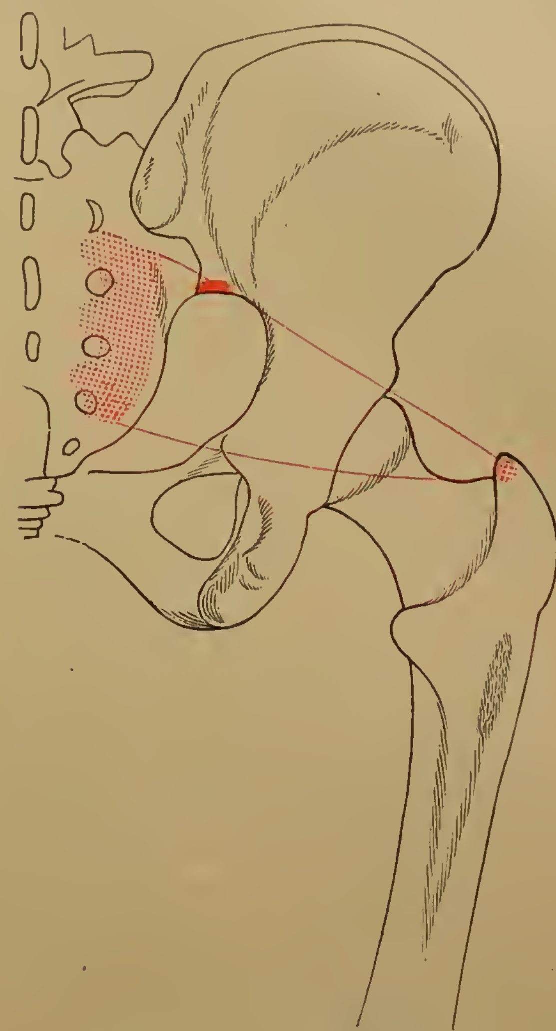

FIG. 365.—Pyriformis of right side: outline and attachment-areas. The muscle is represented in part as if seen through the bones. (F. H. G.)

its origin. *Situation,* largely within the pelvis on its lateral wall, and partly in the upper end of the thigh. *Origin,* the inner surface of the obturator mem-

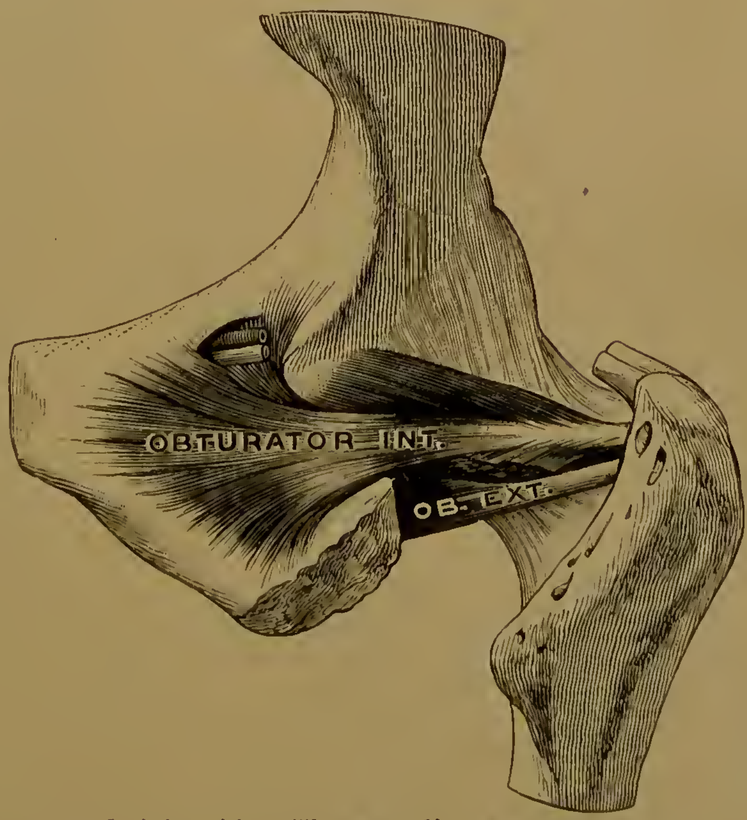

FIG. 366.—Obturator internus of right side. The gemellus superior is shown, but the inferior is mostly removed. (Testut.)

brane; a large irregular area between the obturator foramen, ilio-pectineal line,

FIG. 367.—Sartorius of right side: outline and attachment-areas. (F. H. G.)

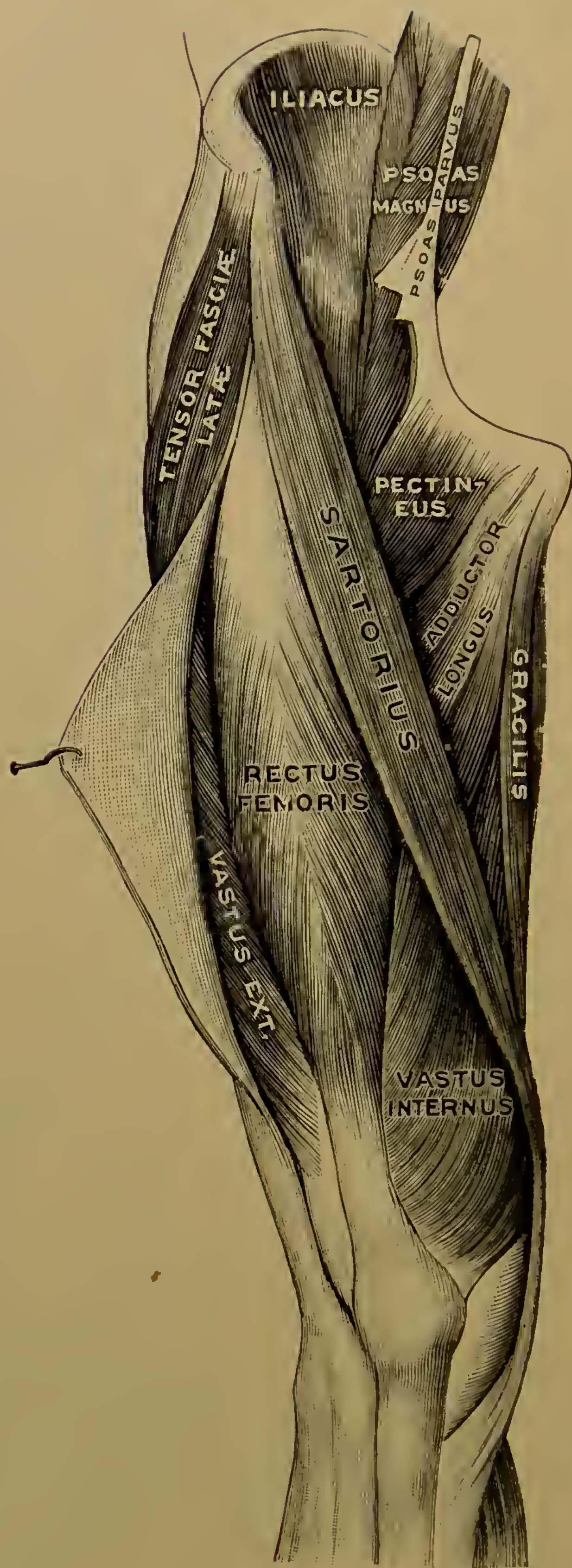

FIG. 368.—Superficial muscles in front part of the right thigh. (Testut.)

and the great sacro-sciatic foramen; the front and lower margins of the obturator foramen. *Direction*, backward to the small sacro-sciatic foramen, around the ischium, and thence outward. *Insertion*, the front part of the inner surface of the great trochanter. *Action*, in extension of the thigh, external rotation; in flexion of the thigh, abduction. *Nerve*, from the sacral plexus.

Gemellus Inferior (Fig. 364).—"The lower little twin muscle." *Situation*, below the tendon of the obturator internus. *Origin*, the upper part of the tuberosity of the ischium. *Direction*, outward. *Insertion*, the front of the inner surface of the great trochanter. *Action*, assistant to the obturator internus. *Nerve*, from the sacral plexus.

MUSCLES MOVING THE LEG.

Flexors.	*Extensor.*
Sartorius.	Quadriceps extensor cruris, comprising:
Biceps flexor cruris.	Rectus femoris.
Semitendinosus.	Vastus externus.
Semimembranosus.	Vastus internus.
Popliteus.	Vastus intermedius.

Of the five flexors three arise from the pelvis alone, one from the pelvis and femur, and one from the femur alone. Thus, four of them cross both the hip- and the knee-joints, and become extensors of the thigh, whenever flexion of the leg is prevented or fully accomplished.

One head of the multiple extensor arises from the pelvis, the others from the femur. The part which crosses the hip-joint as well as the knee-joint acts as a flexor of the thigh, when extension is completed or the knee is fixed.

Sartorius (Figs. 367, 368, 372).—"The tailor's muscle," so called from its action, which assists in producing the cross-legged position assumed by tailors in sitting on the bench. *Situation*, in the front and inner side of the thigh, between the ilium and tibia. *Origin*, the anterior superior iliac spine and part of the notch below. *Direction*, downward and inward across the front of the thigh, then behind the inner condyle of the femur, and finally forward. *Insertion*, the inner surface of the tibia, near the tubercle. *Action*, flexion of the leg and thigh, and synchronous abduction of the thigh; then outward rotation. *Nerve*, the anterior crural.

Biceps Flexor Cruris (Figs. 369, 370, 372).—"The two-headed flexor of the leg." *Situation*, in the back of the thigh, between the ischium and fibula. *Origin*, the long head: the inner impression on the ischial tuberosity, in common with the semitendinosus; the short head: the outer lip of the linea aspera and the upper two-thirds of the outer condylar ridge. *Direction*, downward and a little outward. *Insertion*, the head of the fibula and (slightly) the outer tuberosity of the tibia. Its tendon forms the *outer hamstring*. *Action*, flexion of the leg, and then external rotation; also, from its pelvic origin, extension of the thigh. *Nerve*, the great sciatic.

Semitendinosus (Figs. 369, 371, 372).—"The half tendon muscle." *Situation*, in the back of the thigh toward the inner side, between the ischium and tibia. *Origin*, the inner impression of the ischial tuberosity, in common with the biceps. *Direction*, downward and a little inward. *Insertion*, the upper part of the inner surface of the tibia. *Action*, flexion of the leg, and then inward rotation; also, from its pelvic origin, extension of the thigh. *Nerve*, the great sciatic.

Semimembranosus (Figs. 373, 374, 369).—"The half-membrane muscle," so called from the peculiar disposition of its tendons. *Situation*, in the hind and inner part of the thigh, from the ischium to the tibia. *Origin*, the upper and outer facet of the ischial tuberosity. *Direction*, downward and a little inward.

Insertion, mainly the groove on the back of the inner tuberosity of the tibia; also, a reflection upward and outward to the posterior ligament of the knee, and one downward and outward to the fascia covering the popliteus. *Action*, flexion of the leg, and then inward rotation; also, extension of the thigh. *Nerve*, the great sciatic. The tendons of this muscle, the semitendinosus and the gracilis, form the *inner hamstring*, the outer being formed by the tendon of the biceps.

Popliteus (Figs. 373, 375).—"The ham muscle." *Situation*, behind the knee-joint and in the upper part of the leg. *Origin*,

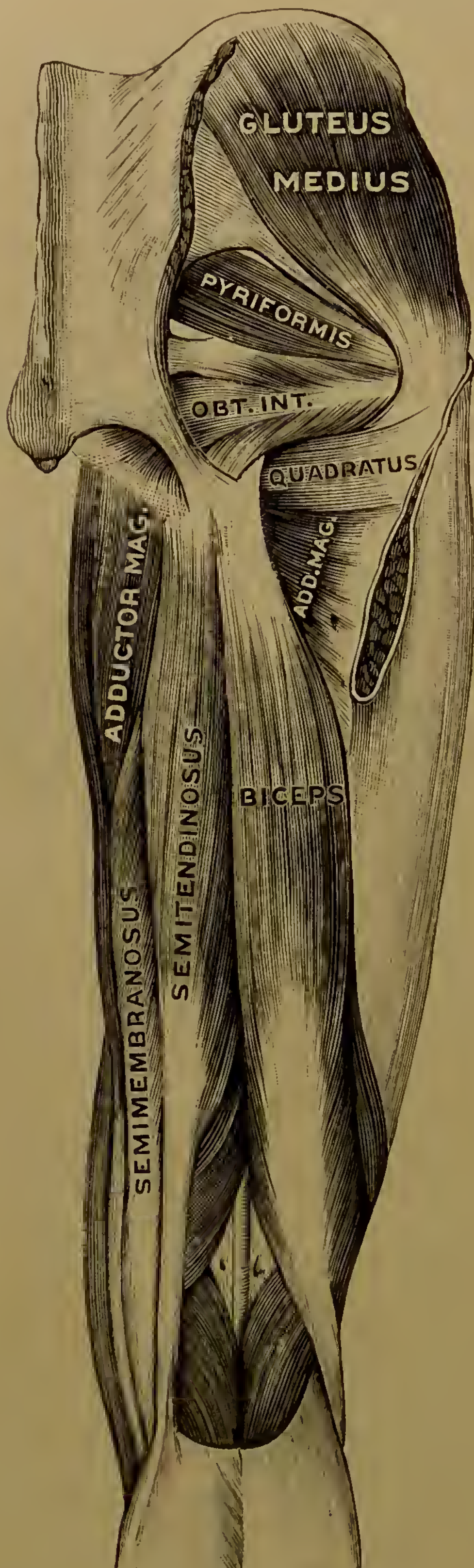

FIG. 369.—Muscles in the dorsum of the right thigh. (Testut.)

FIG. 370.—Biceps flexor cruris of right side: outline and attachment-areas. (F. H. G.)

the outer side of the external condyle of the femur, within the capsule of the joint. *Direction*, down- and inward. *Insertion*, the triangular surface above the oblique

line of the tibia. *Action*, flexion and inward rotation of the leg. *Nerve*, the internal popliteal.

Quadriceps Extensor Cruris.—"The four-headed extensor of the leg." *Synonym*, quadriceps extensor femoris, "the four-headed extensor of the thigh"—a misleading name considered from the physiological point of view, because this muscle does not extend the thigh.

General Description.—Three of the four heads arise from the femur, one from the ilium. Each segment is described as a separate muscle, but all unite in a common tendon of insertion, which is attached to the tubercle of the tibia. The lowest part of this tendon is usually called the *ligamentum patellæ*; but, philosophically considered, it is tendon rather than ligament, and the patella is only a sesamoid bone developed in it, exactly as such osseous formations appear in the short flexor tendons of the great toe. The iliac part of the quadriceps is distinct from the rest nearly to the patella; but the others are more or less blended, and enclose the shaft of the femur to such an extent as to leave hardly anything of it uncovered excepting the linea aspera. The four component parts are the rectus femoris,

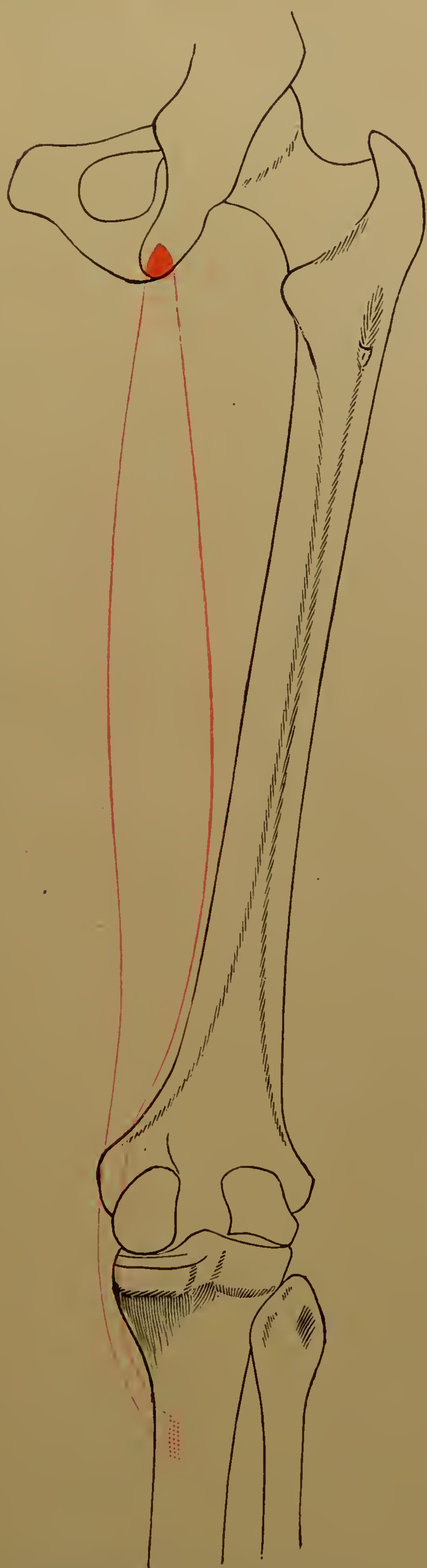

FIG. 371.—Semitendinosus of right side: outline and attachment-areas. (F. H. G.)

FIG. 372.—The inner hamstring muscles at their insertion. (Testut.)

vastus externus, vastus internus, and vastus intermedius, and they will be described separately.

Rectus Femoris (Figs. 368, 376).—"The straight muscle of the thigh." *Situation*, subcutaneous, in the front of the thigh. *Origin*, one head: the anterior inferior iliac spine; the other head: the surface just above the acetabulum. *Direction*, downward and slightly inward. *Insertion*, the upper border of the patella. *Action*, extension of the leg; also, from its iliac origin, slight flexion of the thigh, when the leg is fixed. *Nerve*, the anterior crural.

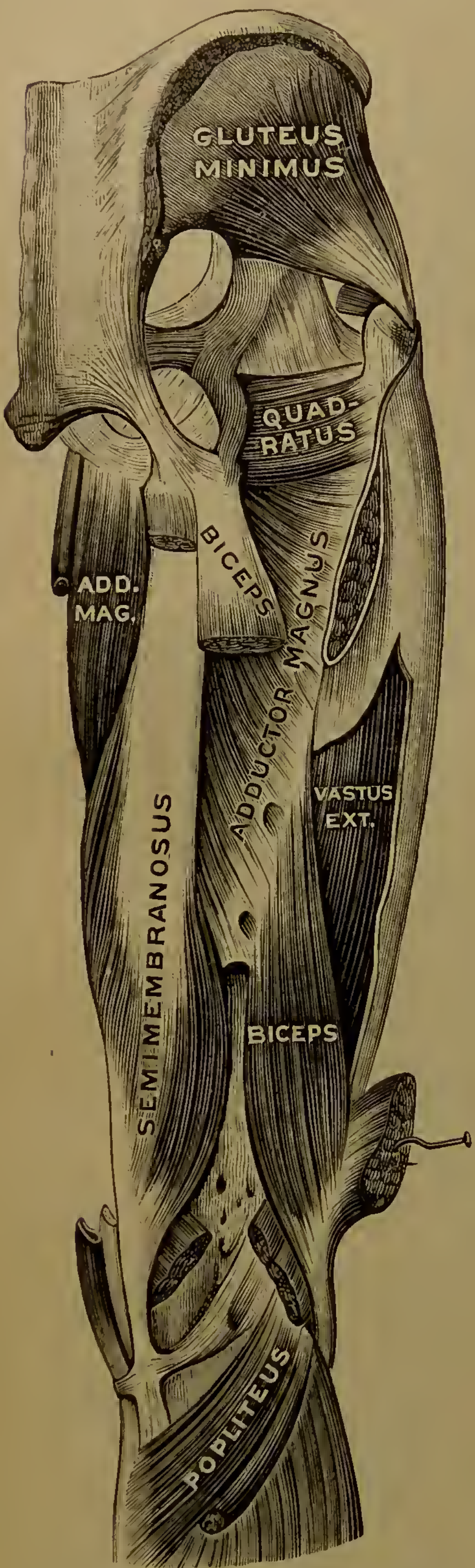

FIG. 373.—Muscles in deep portion of dorsum of right thigh, the semi-tendinosus and most of the biceps having been removed. (Testut.)

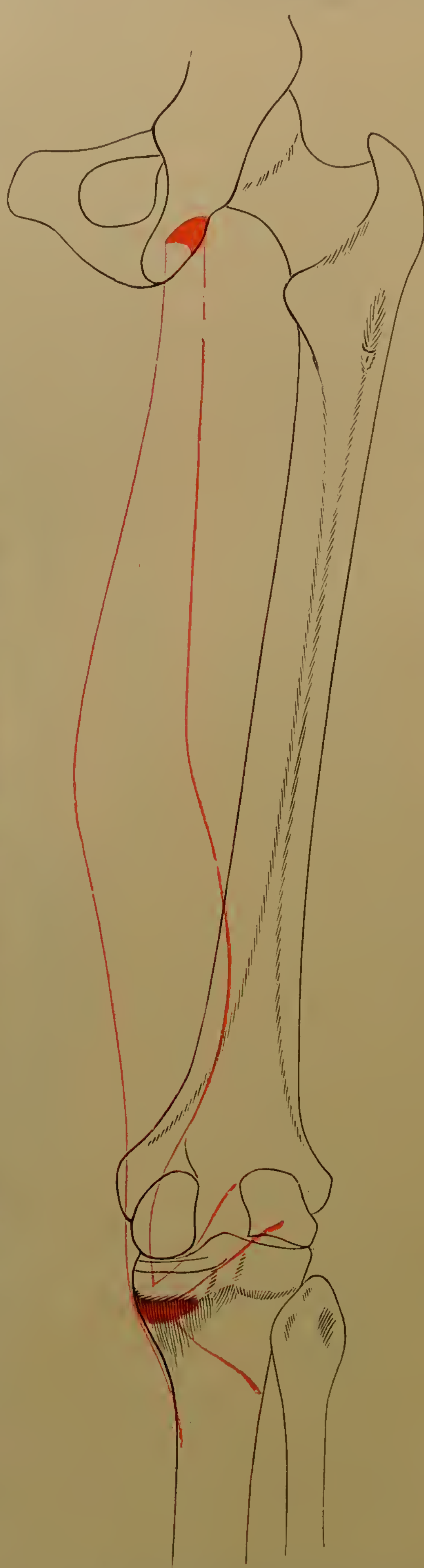

FIG. 374.—Semimembranosus of right side: outline and attachment-areas. (F. H. G.)

FIG. 375.—Popliteus of right side: outline and attachment-areas. (F. H. G.)

FIG. 376.—Rectus femoris of right side: outline d attachment-areas. (F. H. G.)

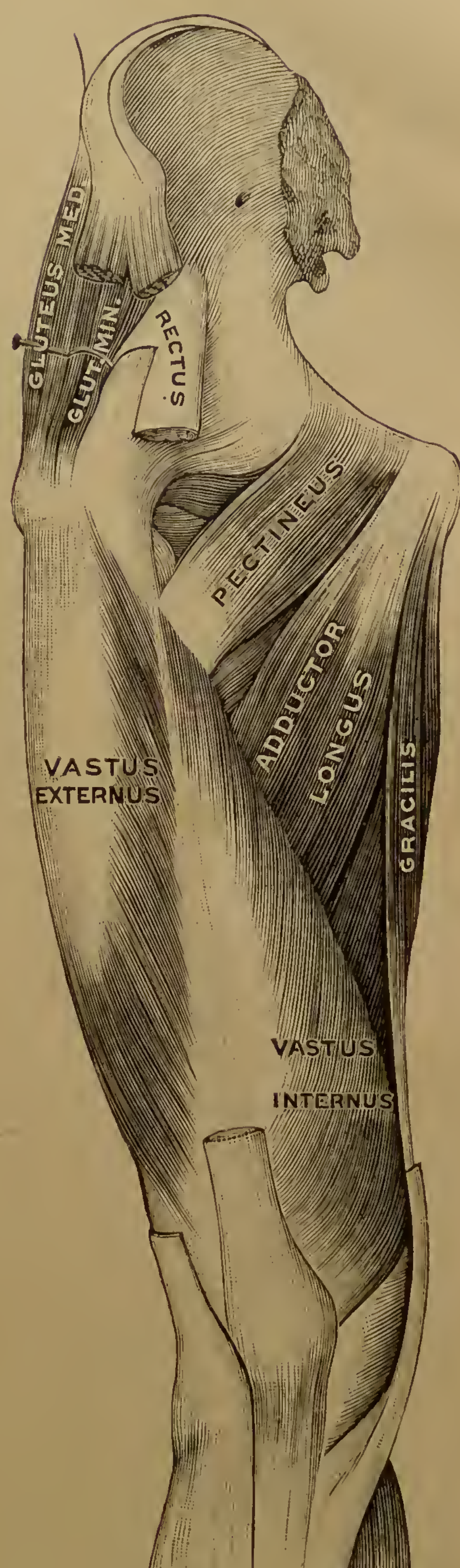

FIG. 377.—Muscles in the right thigh, viewed from in front, after removal of the rectus and sartorius. (Testut.)

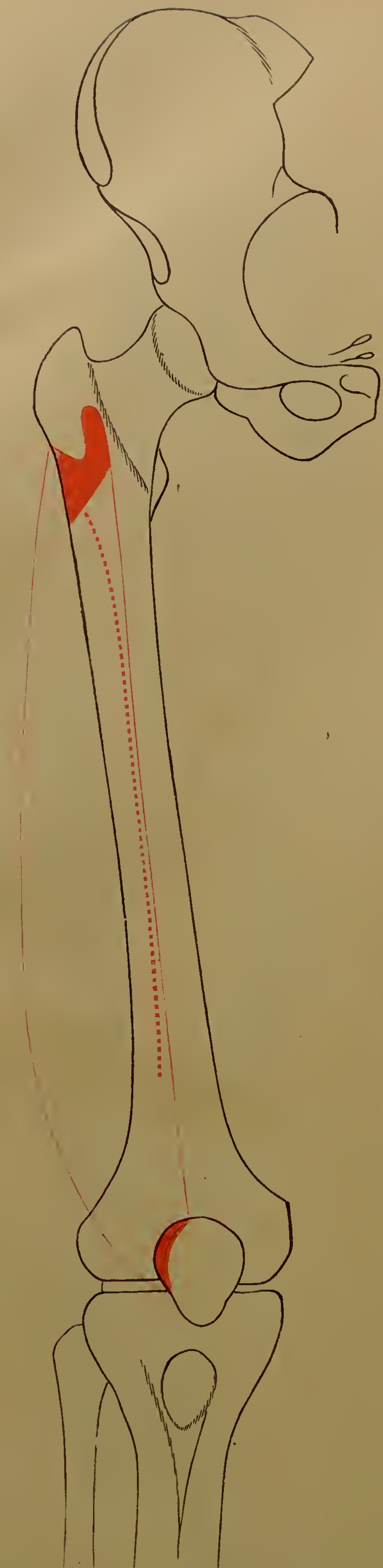

FIG. 378.—Vastus externus of right side: outline and attachment-areas. (F. H. G.)

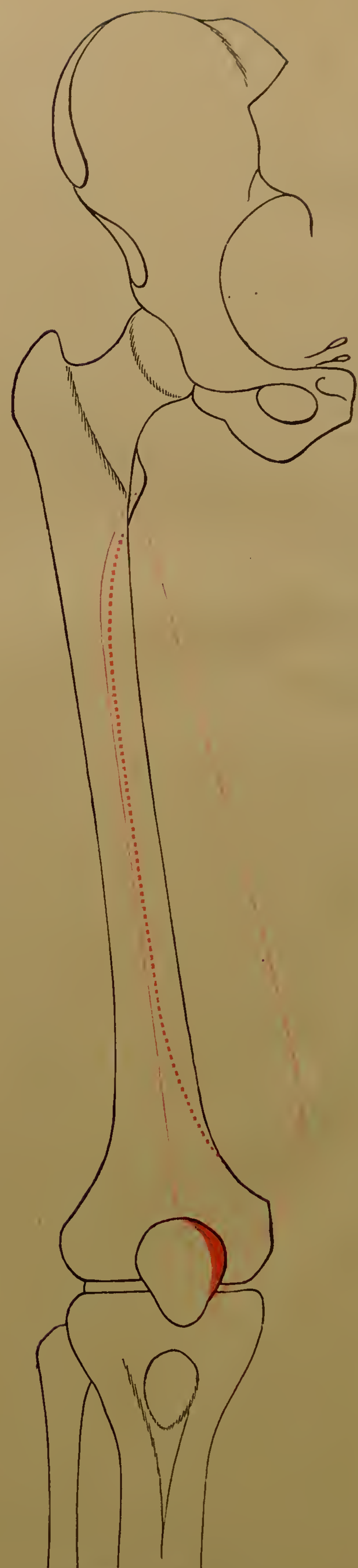

FIG. 379.—Vastus internus of right side: outline and attachment-areas. (F. H. G.)

Vastus Externus (Figs. 377, 378, 368).—"The outer immense muscle." *Synonym*, vastus lateralis, "the lateral immense muscle." *Situation*, the outer part of the thigh, mostly subcutaneous. *Origin*, the anterior intertrochanteric line, the base of the great trochanter, the gluteal ridge, and the outer lip of the linea aspera. *Direction*, down- and forward, then downward and inward. *Insertion*, the upper and outer borders of the patella. *Action*, extension of the leg. *Nerve*, the anterior crural.

Vastus Internus (Figs. 377, 379, 368).—"The internal immense muscle." *Synonym*, vastus medialis, "the immense muscle toward the median line." *Situation*, in the inner part of the thigh, mostly subcutaneous. *Origin*, the lower part of the spiral line of the femur, the inner lip of the linea aspera, and the internal condylar ridge; also, the tendon of the adductor magnus. *Direction*, down- and forward, then down- and outward. *Insertion*, the inner and upper borders of the patella. *Action*, extension of the leg. *Nerve*, the anterior crural.

Vastus Intermedius (Figs. 380, 381).—"The

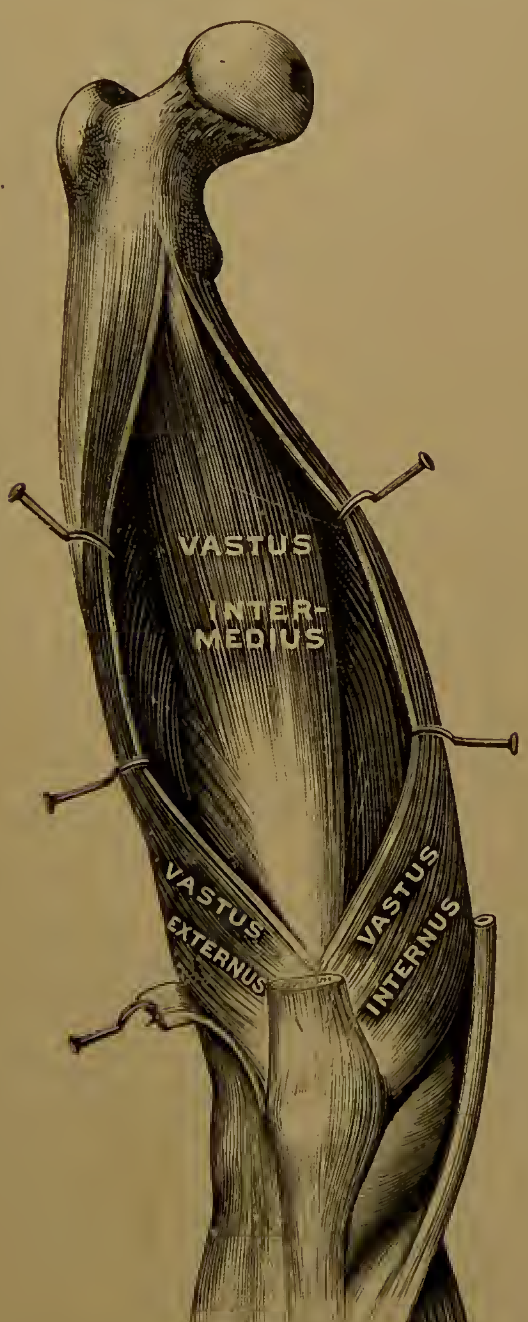

FIG. 380.—Vastus intermedius of right side. (Testut.)

FIG. 381.—Vastus intermedius of right side, outline and attachment-areas. (F. H. G.)

intermediate immense muscle." *Synonym*, crureus, "the leg muscle"—the common name, but very faulty, because it implies location in the leg, whereas this is a muscle altogether in the thigh. *Situation*, close to the shaft of the femur. *Origin*, the upper two-thirds of the anterior surface of the femur, the outer surface in front of and below the origin of the vastus externus, and the lower half of the external intermuscular septum. *Direction*, mainly downward. *Insertion*, the upper border of the patella. *Action*, extension of the leg. *Nerve*, the anterior crural. A narrow interval, extending downward from near the small trochanter, separates the vastus intermedius from the internus. Close to the bone the intermedius and externus are blended, but are distinct from each other elsewhere.

Slightly distal to the lowest part of the origin of the vastus intermedius a few small fasciculi arise from the ventral surface of the femur and pass downward to the proximal part of the synovial membrane of the knee-joint. They are usually spoken of as the subcrureus, but would better be called *musculus articularis genu*, "the knee-joint muscle."

MUSCLES MOVING THE WHOLE FOOT.

Flexors.		*Extensors.*
Tibialis anterior.	(On the inner side.)	Tibialis posterior.
	(Central group.)	Gastrocnemius. Soleus. Plantaris.
Peroneus tertius.	(On the outer side.)	Peroneus longus. Peroneus brevis.

All of these muscles find insertion in the foot, and all arise entirely in the leg, excepting two, which have their origin upon the thigh, and, since they cross both knee- and ankle-joints, are flexors of the leg, when the foot is fixed or fully extended.

The extensors are more numerous and powerful than the flexors, the group which occupies the central position in the leg acting upon the foot purely as extensors. The inner and outer muscles respectively turn the foot inward and outward in addition to their work of flexion and extension.

Tibialis Anterior (Figs. 382, 383).—"The anterior tibial muscle." *Synonym* and commoner name, tibialis anticus. *Situation*, in the front part of the leg and inner side of the foot. *Origin*, the external tuberosity and upper two-thirds of the outer surface of the tibia, and the front of the corresponding and adjacent portion of the interosseous membrane. *Direction*, downward and inward. *Insertion*, the inner surface of the internal cuneiform and the proximal end of the first metatarsal. *Action*, flexion of the foot, elevation of its inner border, and adduction of its distal end. *Nerve*, the anterior tibial.

Peroneus Tertius (Figs. 382, 384).—"The third fibular muscle." *Situation*, in the front of the leg and dorsum of the foot. *Origin*, the lower fourth of the anterior surface of the fibula, and the corresponding and adjacent portion of the interosseous membrane. *Direction*, downward, then forward and outward. *Insertion*, the upper surface of the base of the fifth metatarsal. *Action*, flexion of the foot, elevation of its outer border, and abduction of its distal end. It is inseparable at its origin from the extensor longus digitorum. *Nerve*, the anterior tibial.

Tibialis Posterior (Figs. 385, 386, 394, 398).—"The hind tibial muscle." *Synonym* and commoner name, tibialis posticus. *Situation*, deep in the back part of the leg and inner part of the foot. *Origin*, the hind surface of the interosseous membrane, the upper half of the contiguous portion of the tibia, and the inner surface of the fibula. *Direction*, downward and inward to the back of the inner malleolus, then forward. *Insertion*, the tuberosity of the scaphoid, with offshoots to

the three cuneiform, the cuboid, the bases of the second, third, and fourth metatarsal, and the sustentaculum tali. *Action*, extension of the foot, elevation of its inner border, and adduction of its distal end. *Nerve*, the posterior tibial.

Gastrocnemius (Figs. 387, 388, 391).—"The belly-of-the-leg (or calf) muscle." *Situation*, superficial in the back of the leg. *Origin*, the outer head: the outer side of the external condyle of the femur, and the surface just above; the inner head: the upper part of the inner condyle, and the lower end of the ridge above. *Direction*, downward. *Insertion*, the hind part of the tuberosity of the calcaneum, in common with the

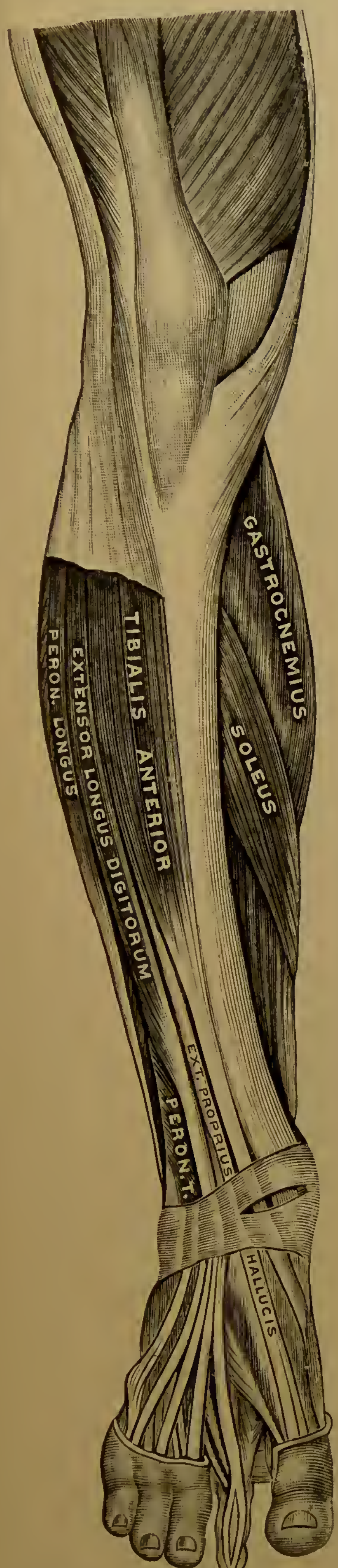

FIG. 382.—Muscles in the right leg, viewed from in front. (Testut.)

FIG. 383.—Tibialis anterior of right side: outline and attachment-areas. (F. H. G.)

FIG. 384.—Peroneus tertius of right side: outline and attachment-areas. (F. H. G.)

soleus. *Action*, extension of the foot; also, when the ankle-joint is fixed, flexion of the leg. *Nerve*, the internal popliteal.

FIG. 385.—Soleus and plantaris of right side. (Testut.)

FIG. 386.—Soleus of right side: outline and attachment-areas. (F. H. G.)

FIG. 387.—Gastrocnemius of right side. (Testut.)

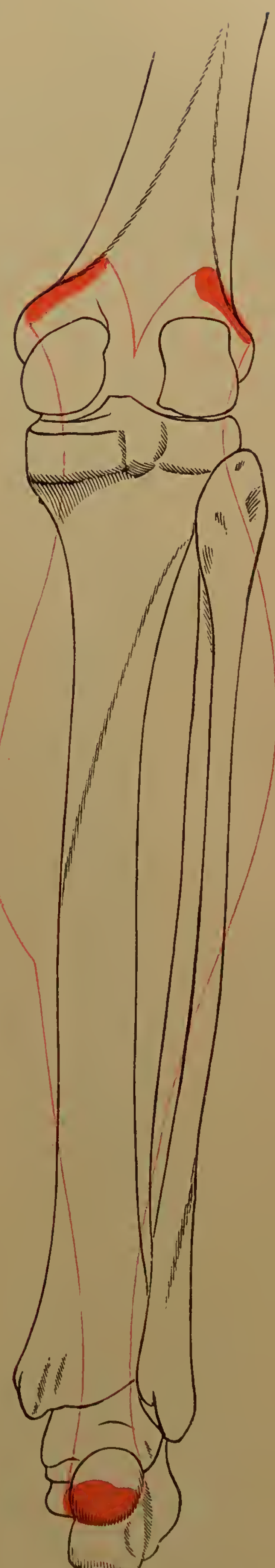

FIG. 388.—Gastrocnemius of right side: outline and attachment-areas. (F. H. G.)

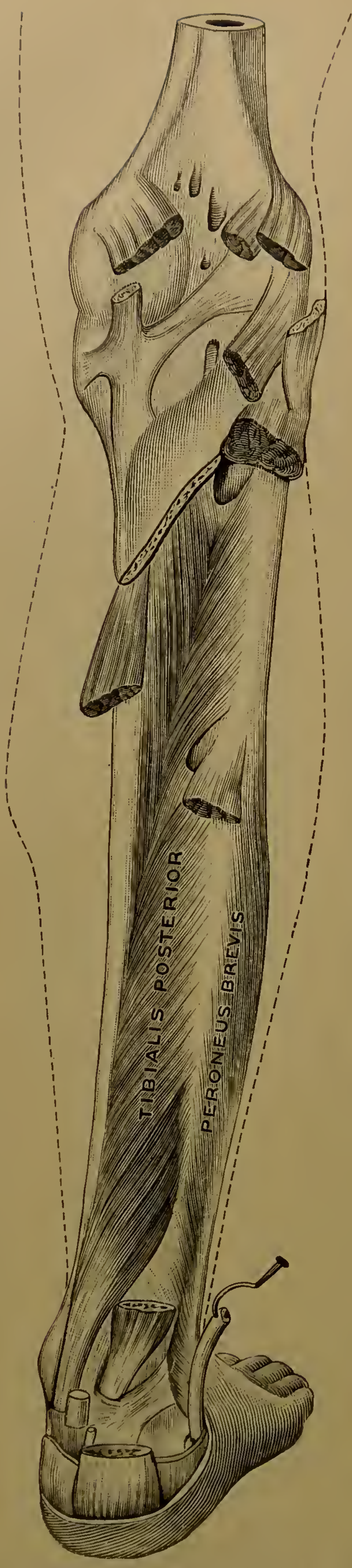

FIG. 389.—Tibialis posterior of right side. (Testut.)

FIG. 390.—Tibialis posterior of right side: outline and attachment-areas. The most of the muscle is represented as if seen through the bones. (F. H. G.)

Soleus (Figs. 389–391).—"The sole-fish muscle," so called from its shape. *Synonym,* gastrocnemius internus, "the internal belly-of-the-leg muscle." *Situation,* in the back part of the leg, in front of the gastrocnemius. *Origin,* the head

FIG. 391.—Muscles in the outer side of right leg and dorsum of foot. (Testut.)

and upper third of the hind surface of the fibula, and the oblique line and internal border of the tibia to the middle of its shaft. *Direction,* downward and a

little backward. *Insertion*, the hind part of the tuberosity of the calcaneum, in common with the gastrocnemius. *Action*, extension of the foot. *Nerves*, the internal popliteal and posterior tibial.

The gastrocnemius and soleus are sometimes and not fancifully considered as a single muscle under the name of *triceps suræ*, "the three-headed muscle of the calf"—the former furnishing two heads, and the latter, one. The common tendon is called *tendo calcaneus*, "the heel tendon," and also more commonly, *tendo Achillis*, "the tendon of Achilles," in allusion to the legendary hero, whose only vulnerable part was his heel. This tendon is the largest in the body, is about six

Fig. 392.—Peroneus longus of right side: outline and attachment-areas. (F. H. G.)

Fig. 393.—Peroneus brevis of right side: outline and attachment-areas. (F. H. G.)

inches long, narrowest at the level of the ankle-joint, and receives muscular fibres almost to its insertion.

Plantaris (Fig. 389).—"The sole-of-the-foot muscle," referring to its occasional insertion into the plantar fascia. *Situation*, in the back of the leg between the gastrocnemius and soleus. *Origin*, the ridge above the external condyle of the

FIG. 394.—Muscles in the deep layer of the dorsum of the right leg. (Testut.)

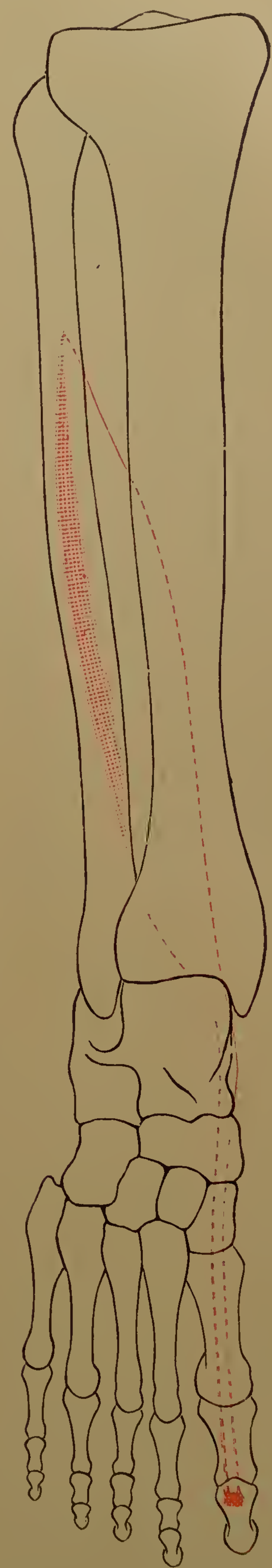

FIG. 395.—Flexor longus hallucis of right side: outline and attachment-areas. The muscle is represented as seen from the front through the bones. (F. H. G.)

femur. *Direction,* downward and inward. *Insertion,* the calcaneum at the inner side of the tendo Achillis. *Action,* extension of the foot and flexion of the leg. *Nerve,* the internal popliteal.

Peroneus Longus (Figs. 391, 392, 394, 398).—"The long fibular muscle." *Situation,* in the outer side of the leg and the sole of the foot. *Origin,* the outer tuberosity of the tibia, the head and upper two-thirds of the outer surface of the fibula. *Direction,* downward to the back of the outer malleolus, forward on the outer side of the calcaneum, through the groove of the cuboid, inward and forward across the sole. *Insertion,* the base of the first metatarsal and the internal cuneiform. *Action,* extension of the foot, elevation of its outer edge, and abduction of its distal end. *Nerve,* the musculo-cutaneous of the external popliteal.

Peroneus Brevis (Figs. 391, 393, 385, 398).—"The short fibular muscle." *Situation,* in the outer side of the leg and foot. *Origin,* the lower two-thirds of the outer surface of the fibula. *Direction,* downward to behind the external malleolus, then forward and a little downward. *Insertion,* the outer side of the tuberosity of the fifth metatarsal. *Action,* extension of the foot, elevation of its outer edge, and abduction of its distal end. *Nerve,* the musculo-cutaneous of the external popliteal.

MUSCLES MOVING THE DIGITS OF THE FOOT.

(Those situated entirely in the foot are indicated by a star.)

Flexors.	*Extensors.*
Flexor longus hallucis.	Extensor proprius hallucis.
*Flexor brevis hallucis.	
Flexor longus digitorum.	Extensor longus digitorum.
*Flexor accessorius.	
*Flexor brevis digitorum.	*Extensor brevis digitorum.
*Flexor brevis minimi digiti.	
*Lumbricales.	

Abductors.	*Adductors.*
*Abductor hallucis.	*Adductor obliquus hallucis.
	*Adductor transversus hallucis.
*Abductor minimi digiti.	
*Interossei dorsales.	*Interossei plantares.

In studying the muscles moving the digits of the foot it is unnecessary to place in a group by themselves those which act upon the great toe, as was done in the case of those of the thumb, for the reason that the first metatarsal bone is as fixed as its four fellows, and does not permit the degree and kind of movement which are so marked a feature of digital action in the hand.

All but four of the twenty-four members of this group are situated entirely in the foot.

Flexor Longus Hallucis (Figs. 394, 395, 398).—"The long flexor of the great toe." *Synonym,* flexor longus pollicis pedis, "the long flexor of the thumb of the foot." *Situation,* deep in the back of the leg on the outer side and in the sole. *Origin,* the lower two-thirds of the hind surface of the fibula, and a little of the interosseous membrane below. *Direction,* downward and inward, behind the inner malleolus, beneath the sustentaculum tali, then forward and inward in the sole. *Insertion,* the under surface of the base of the last phalanx of the first digit. *Action,* flexion of the last phalanx of the great toe. *Nerve,* the posterior tibial.

Flexor Brevis Hallucis (Figs. 396, 399).—"The short flexor of the great toe."

Synonym, flexor brevis pollicis pedis, "the short flexor of the thumb of the foot." *Situation,* in the third layer of the muscles of the sole on the inner side.[1] *Origin,* the inner border and under surface of the cuboid, and the cuneiform tendon of the tibialis posterior. *Direction,* forward and inward. *Insertion,* one (the inner) tendon: the inner side of the base of the first phalanx of the great toe on the plantar aspect, fused with the abductor; the other tendon: the outer side of the same bone, symmetrical with the inner tendon, and conjoined with the adductor. Each of these tendons encloses a sesamoid bone, and between them lies the tendon of the long flexor of the great toe. *Action,* flexion of the whole of the great toe. *Nerve,* the internal plantar.

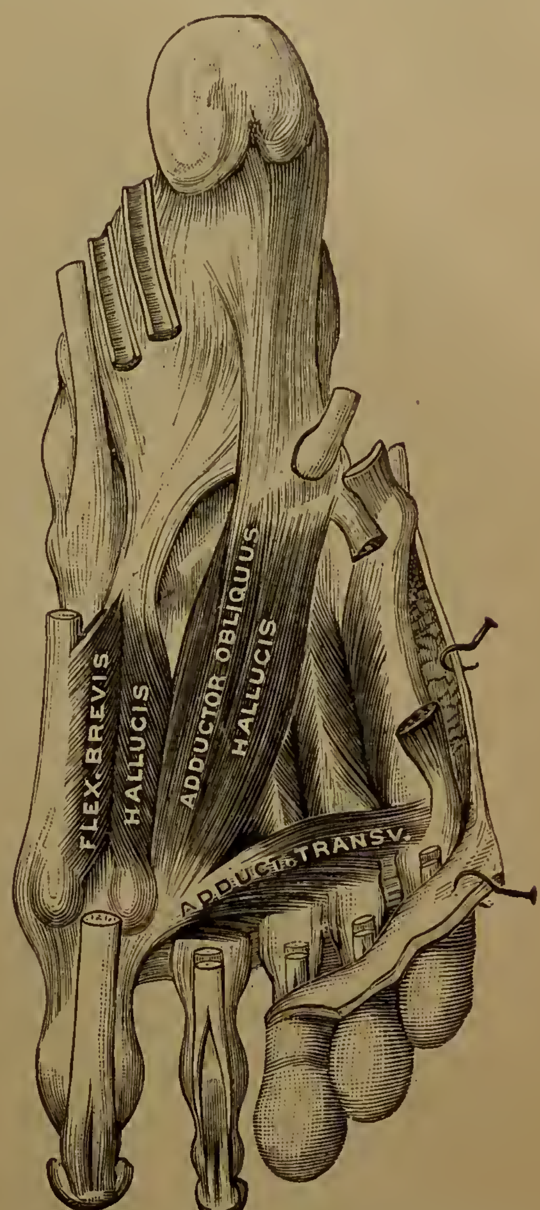

FIG. 396.—Muscles in the third layer of the right sole. The belly of the flexor brevis minimi digiti has been removed. (Testut.)

Flexor Longus Digitorum (Figs. 394, 397, 398).—"The long flexor of the digits" of the foot, meaning the four small toes. *Synonym,* flexor perforans digitorum pedis, "the perforating flexor of the digits of the foot," referring to the passage of its tendons of insertion through the corresponding tendons of the flexor brevis digitorum. *Situation,* deep in the back of the leg on the inner side, and in the sole. *Origin,* the middle two-fourths of the inner part of the hind surface of the tibia. *Direction,* downward behind the inner malleolus, then forward and outward into the sole. *Insertion,* by four tendons, each into the base of a third phalanx on the plantar surface. The undivided tendon is superficial to that of the flexor longus hallucis. Each digital tendon perforates the corresponding tendon of the flexor brevis, just as the flexor profundus perforates the flexor sublimis in the hand. *Action,* flexion of the last phalanges of the four small toes. *Nerve,* the posterior tibial.

Flexor Accessorius (Fig. 399).—"The adjunct flexor," this being assistant to the flexor longus digitorum. *Synonyms,* flexor accessorius digitorum pedis and quadratus plantæ, "the square muscle of the sole." *Situation,* in the hind part of the second muscular layer of the sole. *Origin,* the calcaneum—one head being attached to the inner surface, the other to the outer surface in front of the external tubercle. *Direction,* forward. *Insertion,* the outer (hind) border and upper surface of the tendon of the flexor longus digitorum. *Action,* flexion of the four small toes. It also brings the line of action of the flexor longus digitorum into the long axis of the foot. *Nerve,* the external plantar.

Flexor Brevis Digitorum (Fig. 400).—"The short flexor of the digits," meaning the four small toes. *Synonym,* flexor perforatus digitorum pedis, "the perforated flexor of the digits of the foot." *Situation,* in the first muscular layer of the sole, midway between its sides. *Origin,* the front of the inner tubercle of the calcaneum. *Direction,* forward. *Insertion,* by four tendons into the sides of the second phalanges of the four small toes on their plantar aspect. Each tendon is perforated opposite the first phalanx by the corresponding tendon of the long flexor. *Action,* flexion of the second phalanges of the four small toes. *Nerve,* the internal plantar.

Flexor Brevis Minimi Digiti Pedis (Fig. 399).—"The short flexor of the least

[1] The layers of plantar muscles are numbered from the surface of the sole upward, as they occur in dissection.

digit of the foot"—*i. e.*, of the little toe. *Synonym*, flexor digiti quinti brevis, "the short flexor of the fifth digit." *Situation*, in the third muscular layer of the sole on its outer border. *Origin*, the under surface of the base of the fifth metatarsal. *Direction*, forward. *Insertion*, the outer side of the base of the first phalanx of the fifth toe on its plantar aspect. *Action*, flexion of the fifth toe. *Nerve*, the external plantar.

Lumbricales (Fig. 399).—"The earth-worm muscles," from their fancied resemblance to common angle-worms (*lumbrici*). Each is a lumbricalis. *Number*, four. *Situation*, in the fore part of the second muscular layer of the sole. *Origin*, from the digital tendons of the flexor longus digitorum, the first from the inner margin of the inner tendon, and each of the others from the two tendons between which it lies. *Direction*, forward to the inner side of the four small toes. *Insertion*, the extensor tendon on the dorsum of the first

Fig. 397.—Flexor longus digitorum of right side: outline and attachment-areas. The muscle is represented as seen from in front through the bones. (F. H. G.)

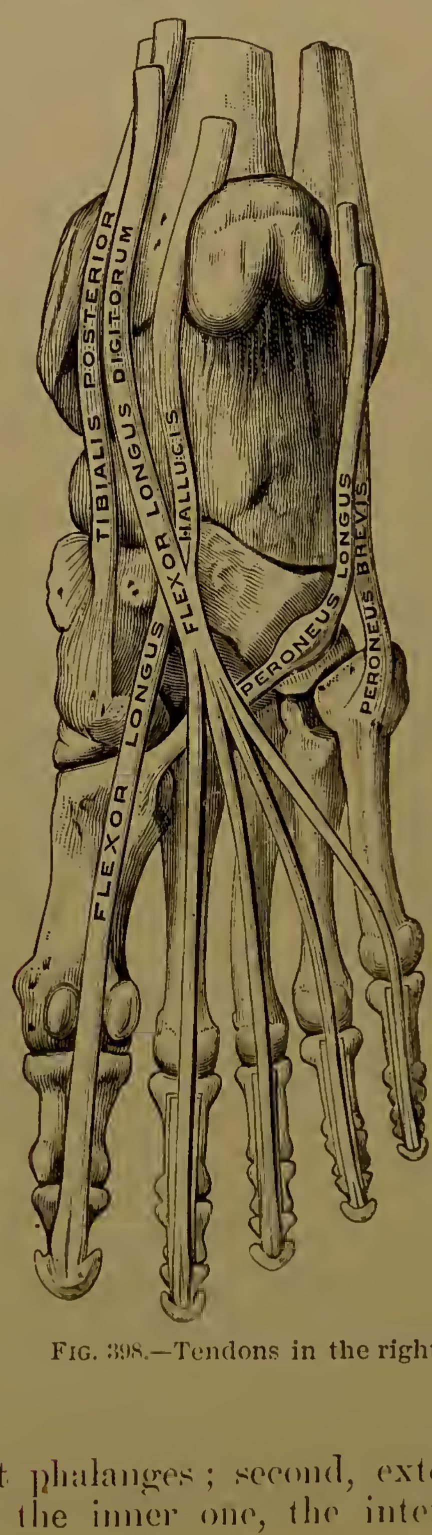

Fig. 398.—Tendons in the right sole. (Testut.)

phalanx. *Action*, first, flexion of the first phalanges; second, extension of the second and third phalanges. *Nerves*, for the inner one, the internal plantar; for the others, the external plantar.

Extensor Proprius Hallucis (Figs. 382, 401, 402).—"The proper extensor of the great toe." *Synonyms*, extensor longus hallucis, extensor proprius pollicis, extensor longus pollicis pedis. "Proprius" is preferable to "longus" in naming this muscle, because extension of the great toe is partly effected through the inner tendon of the extensor brevis digitorum, a muscle not special (proprius) to

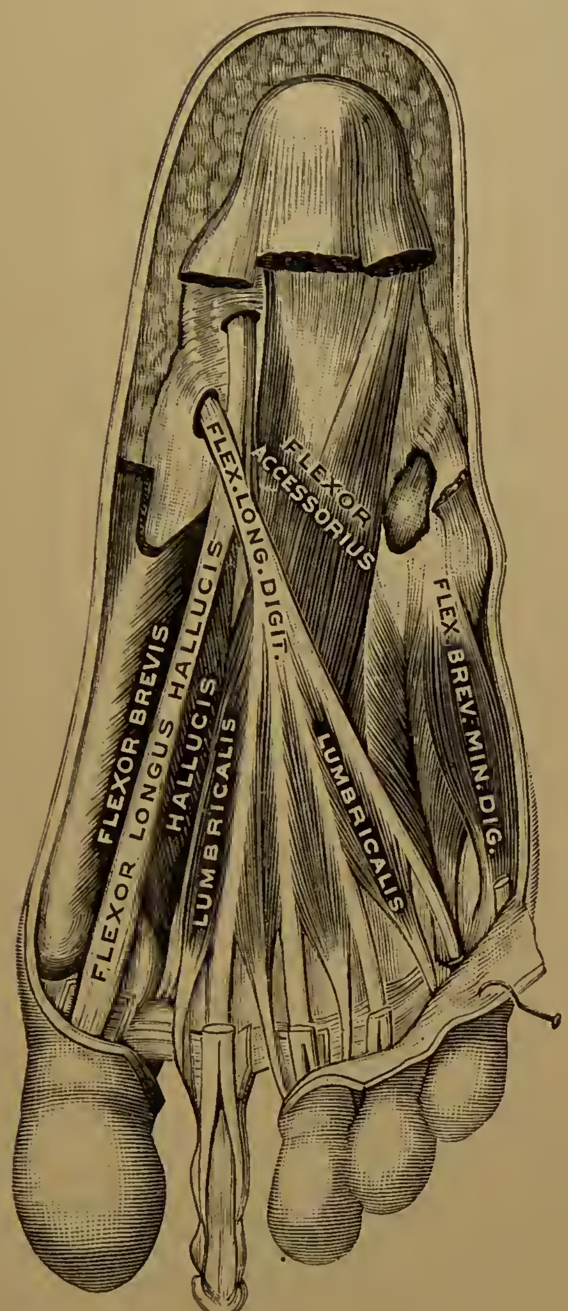

Fig. 399.—Flexor accessorius and lumbricales of right foot. (Testut.)

Fig. 400.—Muscles of the superficial layer of the right foot. (Testut.)

this digit, but also concerned in extending three other toes. *Situation*, in the front of the leg and dorsum of the foot. *Origin*, the middle two-fourths of the anterior surface of the fibula and adjacent part of the interosseous membrane. *Direction*, downward, through the annular ligament, then forward, inward, and a little downward. *Insertion*, the dorsum of the base of the last phalanx of the hallux. *Action*, extension of great toe. *Nerve*, the anterior tibial.

Extensor Longus Digitorum (Figs. 382, 403).—"The long extensor of the digits," meaning the four small toes. *Situation*, in the front of the leg and dorsum of the foot. *Origin*, the external tuberosity of the tibia, the head and two-thirds of the anterior surface of the fibula, and a little of the upper part of the interosseous membrane. *Direction*, downward through the annular ligament, then forward and a little downward. *Insertion*, by a tendon for each of the small toes. Each tendon divides into three parts, of which the middle is attached at the base of the second phalanx on its dorsal aspect, the lateral parts uniting and finding attachment at the base of the last phalanx. *Action*, extension of the four small toes. *Nerve*, the anterior tibial.

Extensor Brevis Digitorum (Figs. 404, 401).—"The short extensor of the

digits" of the foot. *Situation,* in the dorsum of the foot. *Origin,* the front of the upper and outer surface of the calcaneum. *Direction,* forward, and a little inward and downward. *Insertion,* by four tendons: the first at the base of the

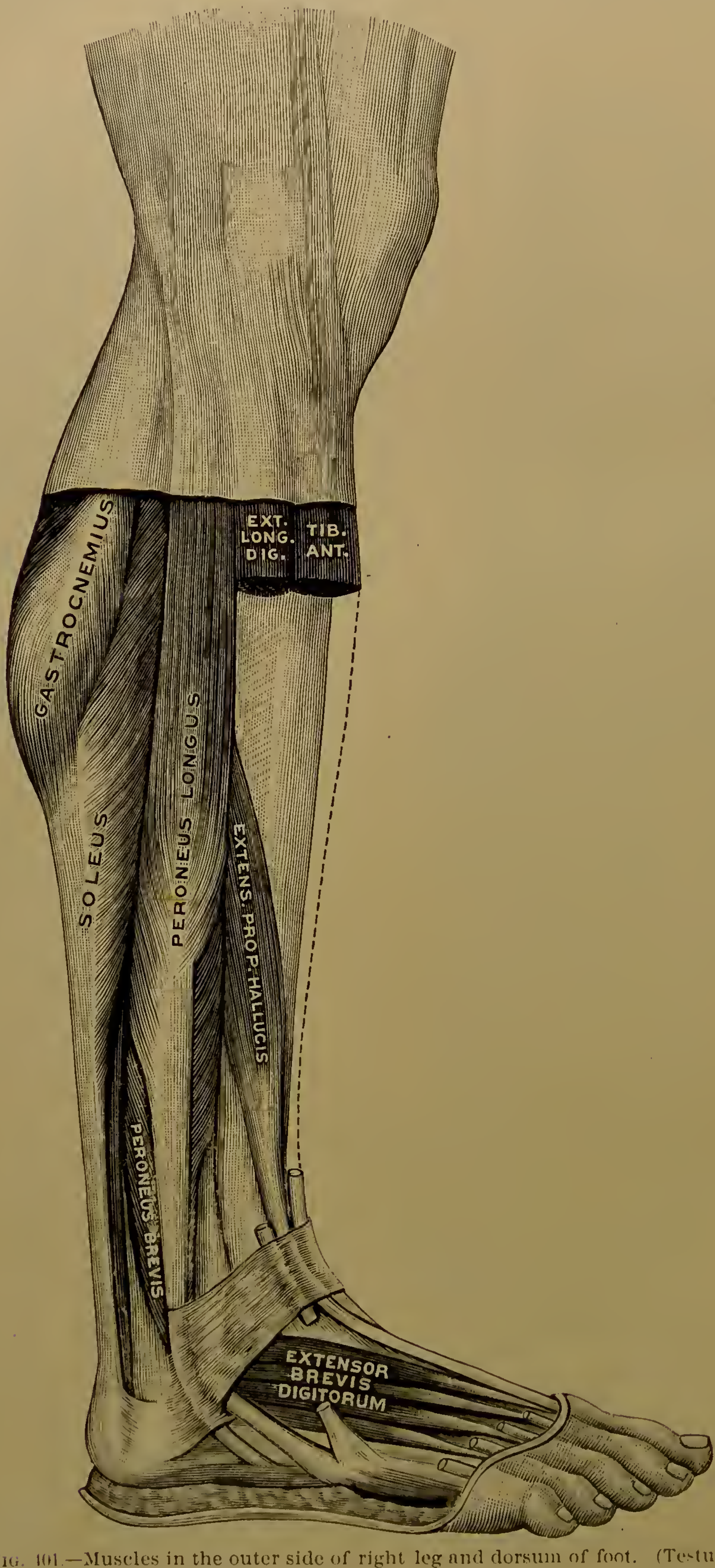

FIG. 101.—Muscles in the outer side of right leg and dorsum of foot. (Testut.)

first phalanx of the great toe on its dorsal aspect; the others on the outer borders of the long extensor tendons of the second, third, and fourth toes respectively.

Action, of the first tendon: extension of the first phalanx of the great toe, and slight adduction; of the others: assistance to the long extensor. *Nerve*, the anterior tibial.

It should be observed that this muscle does not act upon just the same digits as does the long extensor. The extensor brevis is inserted into the great toe, but not into the little; the extensor longus into the little toe, but not into the great.

FIG. 402.—Extensor proprius hallucis of right side: outline and attachment-areas. (F. H. G.)

FIG. 403.—Extensor longus digitorum of right side: outline and attachment-areas. (F. H. G.)

Abductor Hallucis (Figs. 400, 401).—"The abductor of the great toe." *Synonym*, abductor pollicis pedis, "the abductor of the thumb of the foot." *Situation*, in the first muscular layer of the sole on the inner side. *Origin*, the inner tubercle of the calcaneum. *Direction*, forward and a little inward. *Insertion*, the inner side of the base of the first phalanx of the great toe, conjoined with the inner head of the flexor brevis hallucis. *Action*, abduction and flexion of the great toe. *Nerve*, the internal plantar.

Abductor Minimi Digiti Pedis (Figs. 400, 404).—"The abductor of the smallest digit of the foot." *Synonym*, abductor digiti quinti, "the abductor of the fifth digit." *Situation*, in the first muscular layer of the sole on the outer side.

Origin, both tubercles of the calcaneum. *Direction*, forward and a little outward. *Insertion*, the outer side of the base of the first phalanx of the little toe, in common with the short flexor of that toe. *Action*, abduction of the fifth digit. *Nerve*, the external plantar.

Interossei Dorsales Pedis (Fig. 405).—"The dorsal interosseous muscles of the foot." *Number*, four. *Situation*, one in each of the four spaces between the metatarsal bones. *Origin*, each from the adjacent sides of two metatarsal bones. *Direction*, forward. *Insertion*, the bases of the first phalanges, as follows: the first to the inner side of the second toe, the second to the outer side of the second toe, the third to the outer side of the third toe, the fourth to the outer side of the fourth toe;

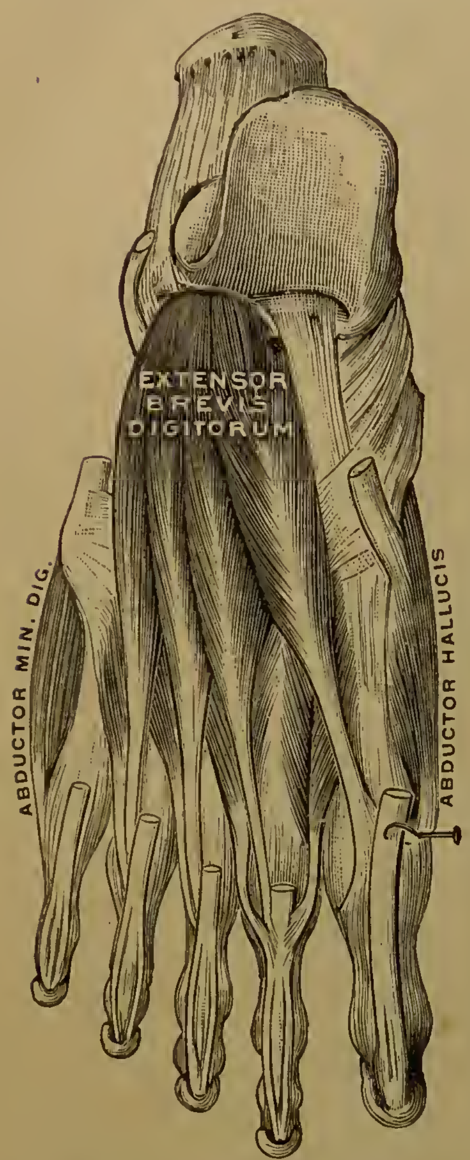

Fig. 404.—Extensor brevis digitorum of right foot. (Testut.)

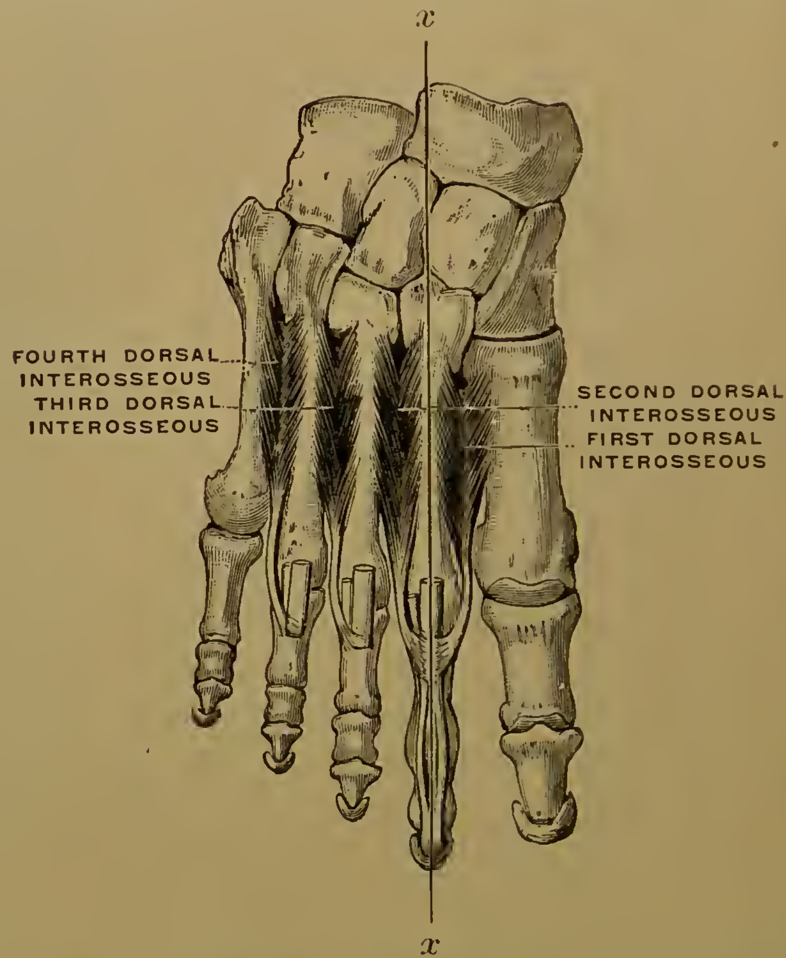

Fig. 405.—Interossei dorsales of right foot. The line xx is that from which abduction is made. (Testut.)

also, each to the extensor tendon of the corresponding toe. *Action*: each abducts from a line drawn through the long axis of the second toe. Those acting on the second toe are alternately abductors and adductors: when one of them has abducted the toe, the other restores it to its attitude of rest by adduction. The dorsal interossei also flex the first phalanges, and afterward extend the second and third. *Nerve*, the external plantar.

Adductor Obliquus Hallucis (Fig. 406).—"The oblique adductor of the great toe." *Synonym*, adductor pollicis pedis, "the adductor of the thumb of the foot." *Situation*, in the fore and middle part of the third muscular layer of the sole. *Origin*, the proximal ends of the second, third, and fourth metatarsals. *Direction*, forward and inward. *Insertion*, the outer side of the base of the first phalanx of the great toe, in common with the adductor transversus and the outer head of the flexor brevis hallucis. *Action*, adduction and flexion of the great toe. *Nerve*, the external plantar.

Adductor Transversus Hallucis (Fig. 406).—"The transverse adductor of the great toe." *Synonym*, transversus pedis, "the transverse muscle of the foot." *Situation*, in the third muscular layer of the sole, across the distal end of the metatarsus. *Origin*, the lower metatarso-phalangeal ligaments of the outer three toes and the transverse metatarsal ligament. *Direction*, transversely inward.

Insertion, the base of the first phalanx of the great toe, conjointly with the adductor obliquus and the outer head of the flexor brevis. *Action,* adduction of the great toe. *Nerve,* the external plantar.

Interossei Plantares (Fig. 407).—"The plantar interosseous muscles." *Number,* three. *Situation,* the second, third, and fourth spaces between the metatarsal bones, on the plantar aspect. *Origin,* the inner and under surfaces of metatarsal bones, as follows: the first on the third bone, the second on the fourth, the third on the fifth. *Direction,* forward. *Insertion,* each on the inner side of the base of the first phalanx of the corresponding toe and its extensor tendon. *Action,* adduction toward the second toe; also, flexion of the first phalanges, and afterward extension of the second and third phalanges. *Nerve,* the external plantar.

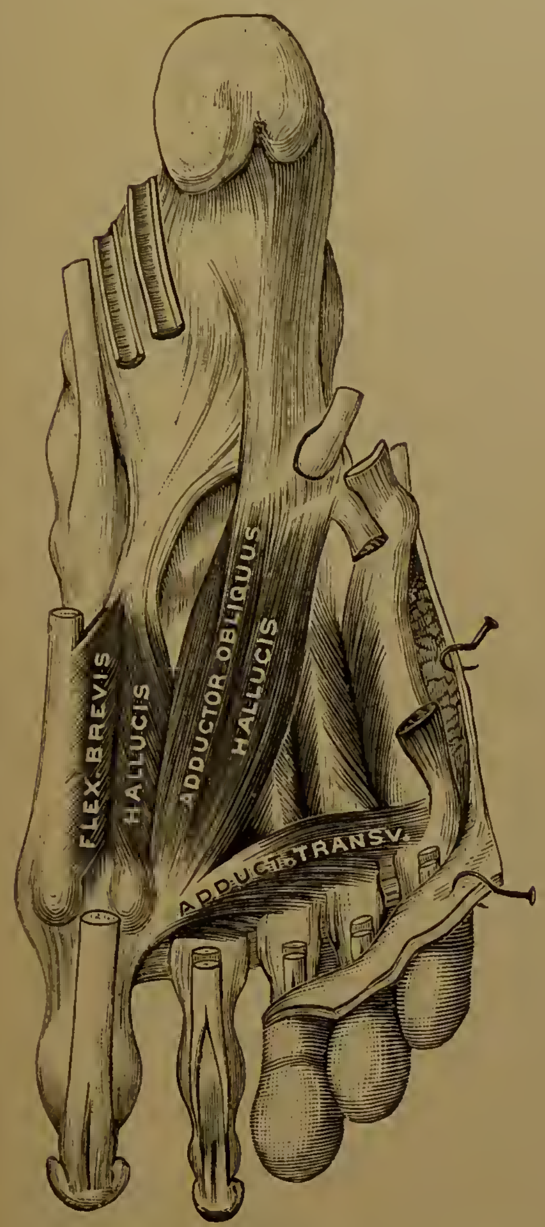

Fig. 406.—Muscles in the third layer of the right sole. (Testut.)

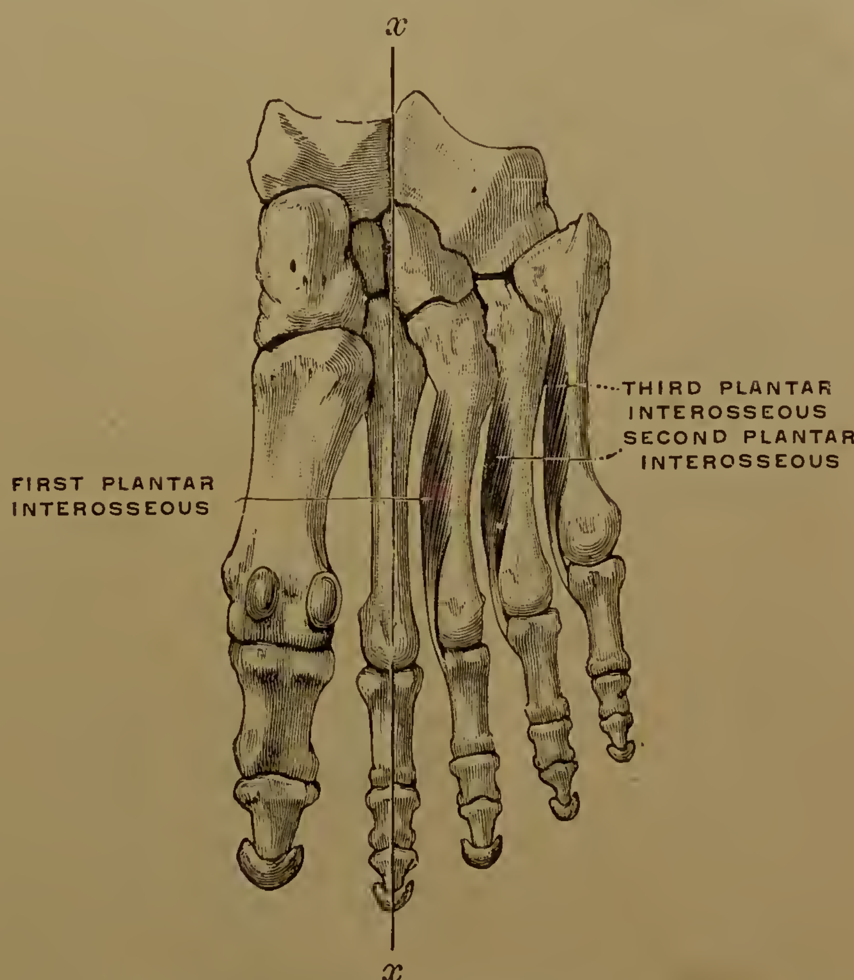

Fig. 407.—Interossei plantares of right foot. The line *xx* is that to which adduction is made. (Testut.)

The interosseous muscles, the abductor and the two adductors of the hallux, and the abductor minimi digiti are physiologically upon the same plane, forming a group whose members produce the lateral movements of the toes. The great toe has one muscle (abductor hallucis) inserted on the inner side of the base of the first phalanx, and two adductors on the opposite side of the same bone; each of the other toes has two muscles similarly attached. They are arranged as follows, the inner muscle in each case being named first: the second toe has the first dorsal interosseous and the second dorsal interosseous; the third toe has the first plantar interosseous and the third dorsal; the fourth toe has the second plantar interosseous and the fourth dorsal; the fifth toe has the third plantar interosseous and the abductor minimi digiti. The interossei inserted upon the second toe are alternately abductors and adductors; the other dorsal interossei are always abductors, and all of the plantar interossei are adductors, the middle line of the second toe when at rest being the line from and to which movements are reckoned. Compare this arrangement with that of the homologous parts in the upper limb.

Psoas Parvus (Fig. 345).—"The little loin-muscle" is small, flat, inconstant, of irregular origin, situated in front of the psoas magnus. Most frequently it arises from the bodies of

the lowest thoracic and the highest lumbar vertebræ and the disc between them. Its body is short, and its long tendon, blended with the iliac fascia, is inserted into the ilio-pectineal eminence. It is a tensor of the iliac fascia.

Muscles which Move the Lower Limb, Grouped according to Their Location.

In the Pelvis and Upper Part of the Thigh.

Psoas magnus.	Iliacus.

In the Region of the Buttock.

Gluteus maximus.	Pyriformis.	Obturator internus.
Gluteus medius.	Obturator externus.	Gemellus inferior.
Gluteus minimus.	Gemellus superior.	Quadratus femoris.

In the Front of the Thigh.

Tensor vaginæ femoris.	Rectus femoris.	Vastus internus.
Sartorius.	Vastus externus.	Vastus intermedius.

In the Back of the Thigh.

Semimembranosus.	Semitendinosus.	Biceps flexor cruris.

In the Mesial Part of the Thigh.

Adductor magnus.	Adductor brevis.	Pectineus.
Adductor longus.	Adductor gracilis.	

In the Front of the Leg.

Tibialis anterior.	Extensor proprius hallucis.
Extensor longus digitorum.	Peroneus tertius.

In the Outer Part of the Leg.

Peroneus longus.	Peroneus brevis.

In the Back of the Leg.

Gastrocnemius. Soleus. Plantaris.	*Superficial group.*	Popliteus. Flexor longus hallucis. Flexor longus digitorum. Tibialis posterior.	*Deep group.*

In the Dorsum of the Foot.

Extensor brevis digitorum.

In the Sole of the Foot.

Abductor hallucis. Flexor brevis digitorum. Abductor minimi digiti.	*First (superficial) layer.*	Flexor accessorius. Lumbricales.	*Second layer.*
Flexor brevis hallucis. Adductor obliquus hallucis. Adductor transversus hallucis. Flexor brevis minimi digiti.	*Third layer.*	Interossei plantares. Interossei dorsales pedis.	*Fourth layer.*

The muscles of the lower limb having been considered in groups according to their function and according to their situation, it is advisable for the student now to make other classifications of them, in order to view them from as many points as possible, and thus obtain a more intimate acquaintance with the subject. Let him arrange them according to *the bones which they connect,* as those connecting the hip-bone with the femur, with the tibia, with the fibula; the femur with the vertebral column, with the tibia, with the fibula, with the calcaneum; the tibia with tarsal bones, with metatarsal bones, with phalanges; and so on. Then let him study them in *their relations to their immediate neighbors,* as shown by plane sections made at different levels. Some of the figures in the chapter on the arteries will be of great assistance in this matter. When he has learned the descriptive anatomy of the nerves, he would do well to review his myology, and group all of the muscles on the basis of *their nerve-supply.* Other methods may be adopted—the more the better for the student's improvement; but those suggested are among the best.

THE MUSCLES OF THE TRUNK.

These will be considered in three groups, as follows :

A. The muscles of the *back*, including those in the dorsum of the neck.
B. The muscles of the *abdomen*.
C. The muscles of the *thorax*.

THE MUSCLES OF THE BACK, including the Dorsum of the Neck.

The muscles situated in the back of the trunk and neck are arranged in a number of groups, which are usually described as layers, although the lamination of those most deeply located is not distinct.

The first, or *superficial layer*, comprising the trapezius and latissimus, and the *second layer*, made up of the levator scapulæ and the two rhomboidei, have already been described in connection with the muscles of the upper limb, as they functionally belong in that class.

Muscles in the Third Layer of the Back.

Serratus posterior superior.	Splenius capitis.
Serratus posterior inferior.	Splenius cervicis.

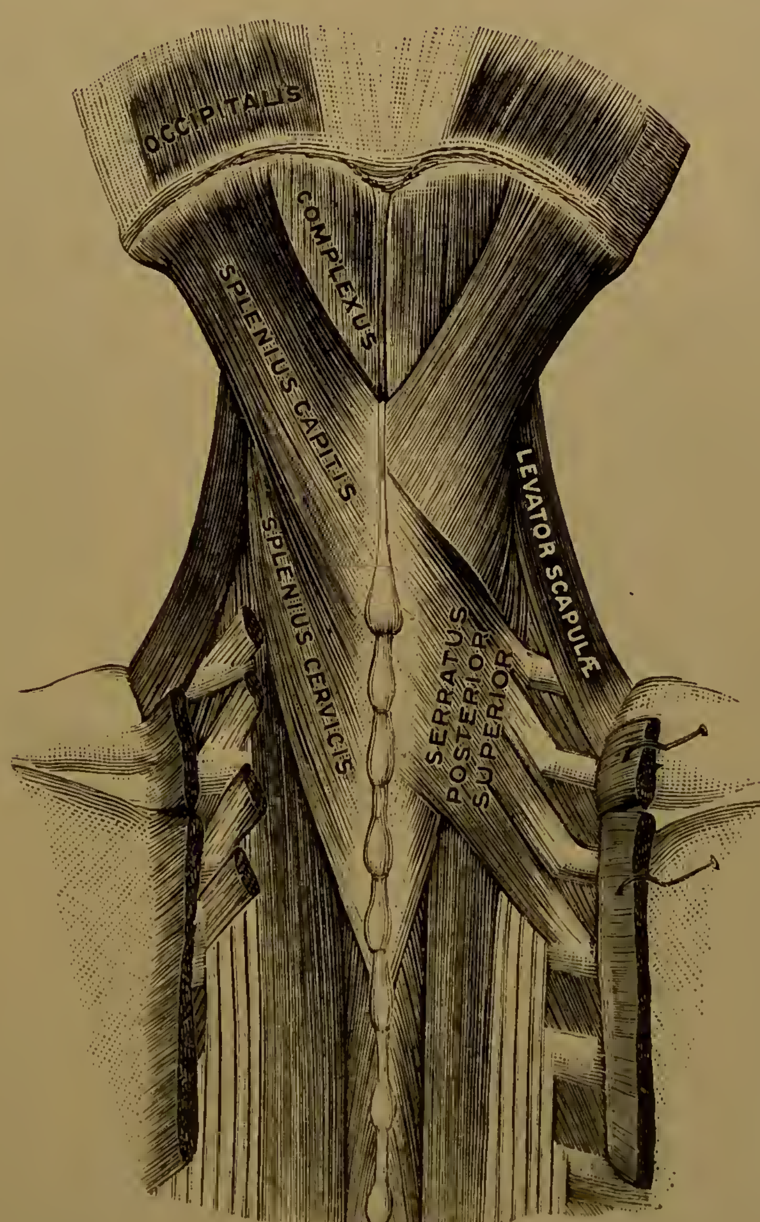

Fig. 408.—Muscles in the third layer of the back. The serratus posterior inferior is shown in the next figure. (Testut.)

Serratus Posterior Inferior (Fig. 408).—"The upper, hind, saw-toothed muscle." *Synonym*, serratus posticus superior. *Situation*, at the base of the neck and upper part of the thorax, nearly covered by the levator scapulæ and rhomboidei. *Ori-*

gin, the lower part of the nape ligament, and the spines of the last cervical and two or three upper thoracic vertebræ. *Direction*, down- and outward. *Insertion*, the second, third, fourth, and fifth ribs beyond their angles. *Action*, elevation of the ribs of its insertion. *Nerves*, the second and third intercostals.

Serratus Posterior Inferior (Fig. 409).—"The lower, hind, saw-toothed muscle." *Synonym*, serratus posticus inferior. *Situation*, the upper loin and lower thoracic regions. *Origin*, the spines of the lower two thoracic and upper two or three lumbar vertebræ. *Direction*, outward and upward. *Insertion*, the lower borders of the lower four or five ribs, beyond the line of the costal angles. *Action*: it draws the lower ribs backward and downward. *Nerves*, the tenth and eleventh intercostal.

Splenius Capitis (Fig. 408).—"The strap-shaped muscle of the head." *Situation*, in the back of the

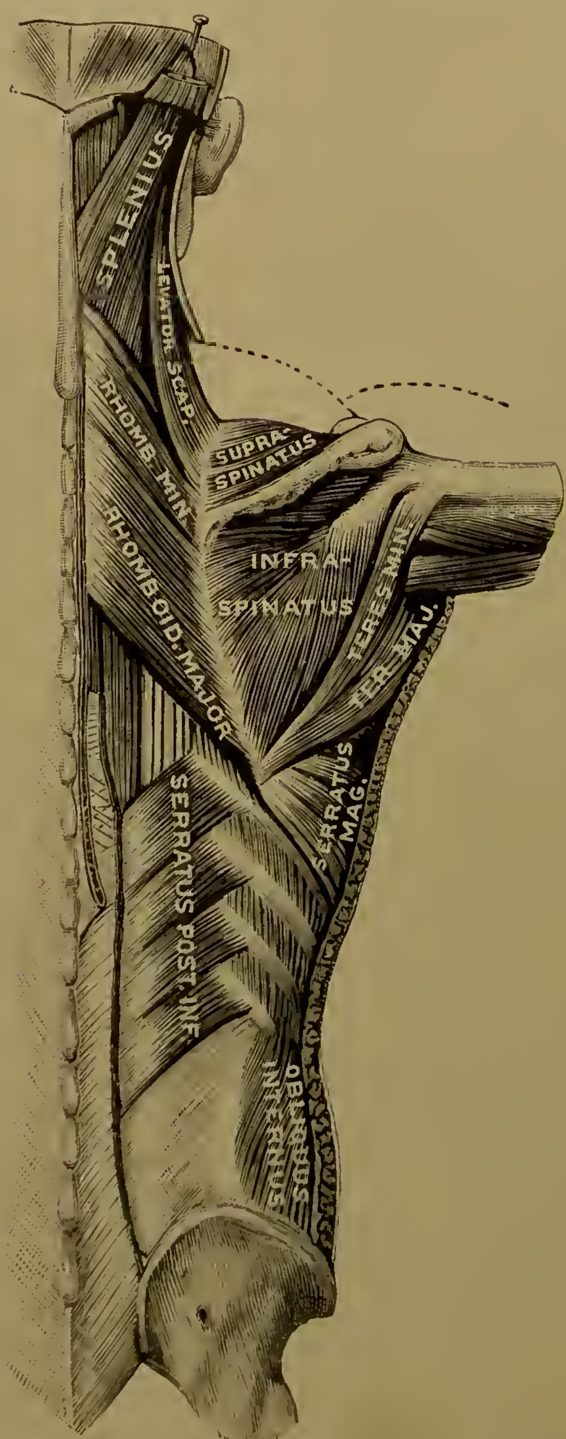

Fig. 409.—Muscles in the second layer of the back and on the dorsum of the shoulder. (Testut.)

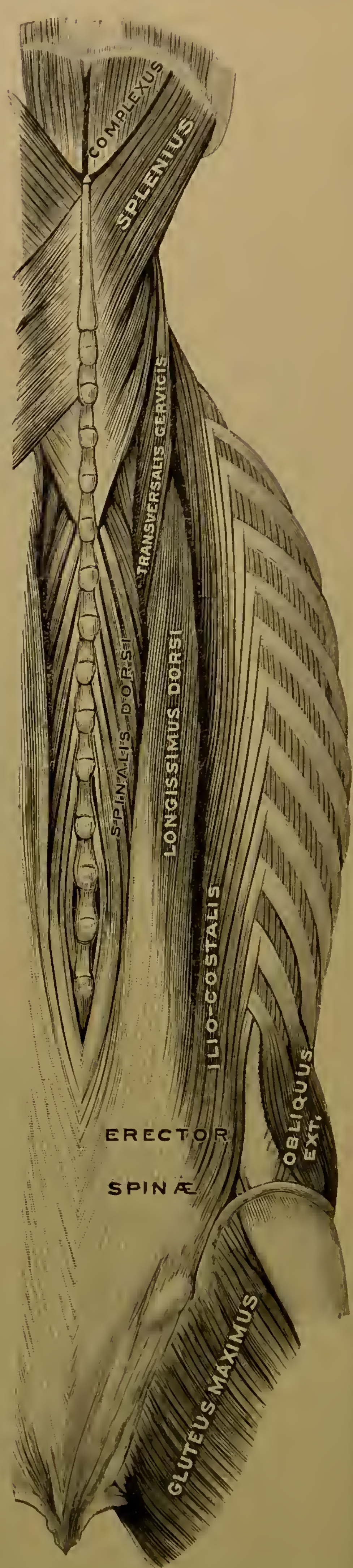

Fig. 410.—Erector spinæ, superficial view. (Testut.)

neck, in front of the trapezius. *Origin,* the lower two-thirds of the nape ligament, and the spines of the seventh cervical and first and second thoracic vertebræ. *Direction,* upward and outward. *Insertion,* the mastoid process of the temporal, and the superior curved line of the occipital. *Action,* extension of the head, and its rotation to the side on which the muscle lies. *Nerve,* external branches of the dorsal primary divisions of the middle cervical.

Splenius Cervicis (Fig. 408).—"The strap-shaped muscle of the neck." *Synonym,* splenius colli. *Situation,* in the back of the neck, in front of the trapezius. *Origin,* the spines of the third, fourth, and fifth thoracic vertebræ. *Direction,* upward, outward, and forward. *Insertion,* the hind tubercles of the transverse processes of the upper two, three, or four cervical vertebræ. *Action,* extension of the neck, and its rotation to the side on which the muscle lies. *Nerves,* external branches of the dorsal primary divisions of the lower cervical.

Muscles in the Fourth Layer of the Back.

The *fourth layer* is formed by the erector spinæ (the erector of the spine—that is, the muscle which extends it). It constitutes the greater part of the long, rounded mass, which runs parallel to the series of vertebral spinous processes, and projects so far backward that, when a view is taken of the entire back, the bones seem to be sunk in a valley between two mounds, instead of protruding conspicuously, as in the skeleton.

The **Erector Spinæ** (Fig. 410) is a compound muscle, beginning below in a single mass, but soon dividing into three portions, which pass upward and end at different heights, that nearest the middle line going no further than the upper part of the thorax, the outermost passing well into the neck, and the middle reaching to the base of the skull. The second and third of these do not proceed to their respective destinations uninterruptedly, but by a series of steps, each making three. The arrangement suggests the simile of scaling a cliff: as the muscle climbs up the back, it does not relinquish one foothold until it has established a new one—it takes a fresh grip before it lets go the old; and, as a result, there is not merely continuity of structure, but overlapping, one segment beginning back (sometimes far back) of the ending of the segment below it. The various portions are described as separate muscles. The name erector spinæ properly includes them all; but it is often used in a restricted sense to designate the undivided mass from which these prolongations arise.

Scheme of the Erector Spinæ.

Erector spinæ:

- *Outer division* :
  - Ilio-costalis.
    - Accessorius ad ilio-costalem.
      - Cervicalis ascendens.
- *Middle division* :
  - Longissimus dorsi.
    - Transversalis cervicis.
      - Trachelo-mastoideus.
- *Inner division* :
  - Spinalis dorsi.

The **Erector Spinæ** arises from the lowest two or three thoracic and all of the lumbar and sacral spines, the transverse processes of several lower thoracic vertebræ, the lower and back part of the sacrum, and the hind fifth of the iliac crest. From this beginning come the three divisions—the outer, the middle, and the inner.

The **outer division** starts off just below the last rib as the *ilio-costalis* (Fig. 410), so called from its connecting the ilium with certain ribs. It is also known

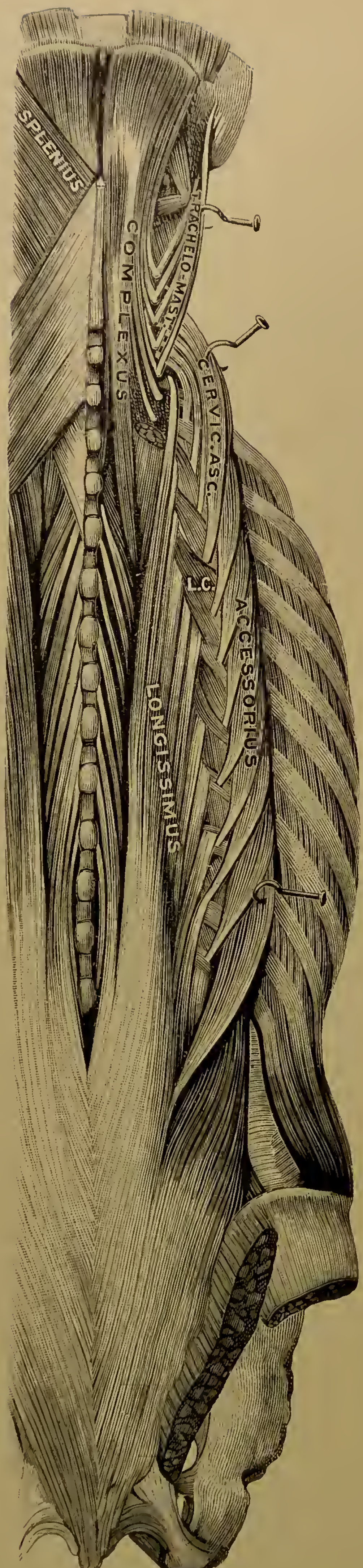

FIG. 411.—Erector spinæ. The outer series is pulled outward. (Testut.)

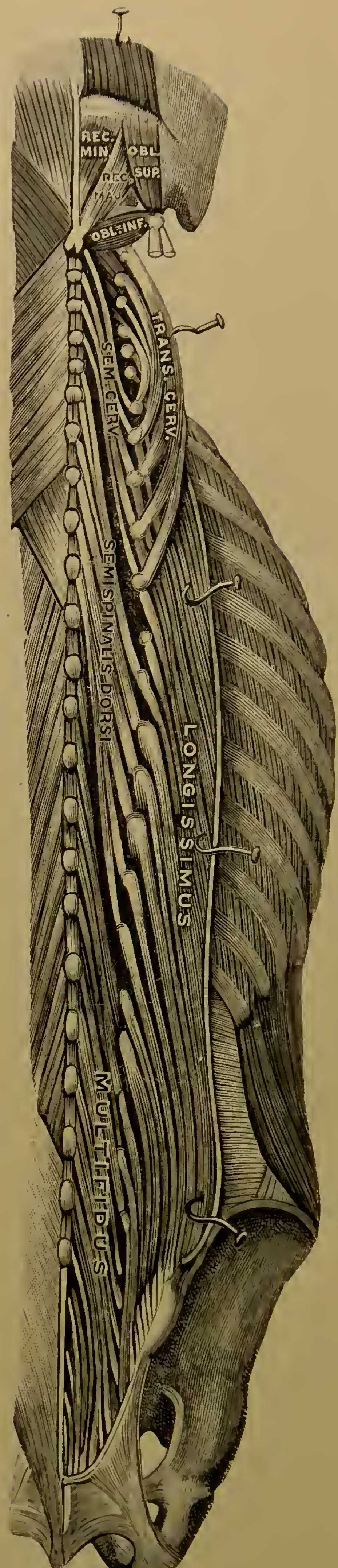

FIG. 412.—Erector spinæ. The middle series is pulled outward. (Testut.)

as the sacro-lumbalis, as it begins in the sacral region and runs to the lumbar. It is inserted into the lower six or seven ribs at their angles, or in the line of the costal angles. From the same ribs, a trifle toward the middle line from these points of insertion, springs the *accessorius ad ilio-costalem* (Fig. 411), "the adjunct to the ilio-costalis," which passes up and is inserted into the upper six ribs (at the angles of those below the first, and on that one near the tubercle), and the transverse process of the vertebra prominens. On the four or five ribs above those from which the accessorius arises, a little mesially from its line of costal insertion, are the points of origin of the *cervicalis ascendens* (Fig. 411), "the ascending neck muscle," which thus sustains a relation to the accessorius like that of the latter to the ilio-costalis. It is inserted into the transverse processes of the fourth, fifth, and sixth cervical vertebræ. These three muscles—the ilio-costalis, accessorius, and cervicalis ascendens—are in appearance and in effect practically one.

The **middle** and largest **division** of the erector spinæ begins as the *longissimus dorsi* (Figs. 410–412), "the longest muscle of the back." It is inserted into the transverse processes of all the thoracic and the accessory processes of the lumbar vertebræ, and into most of the ribs between the tubercles and angles. Its upward prolongation is called *transversalis cervicis* (Figs. 410–412), a name which refers to the attachments of the muscle to transverse processes. It arises from the transverse processes of from four to six upper thoracic vertebræ, internally to the insertions of the longissimus, and is inserted into the transverse processes of cervical vertebræ from the second to the sixth. The last segment of this division is the *trachelo-mastoideus* (Figs. 411–413), "the neck-mastoid muscle," so called from its situation and insertion. It arises from the transverse processes of from four to six upper thoracic vertebræ with the transversalis cervicis, and also from the articular processes of the lower three or four cervical; and it is inserted into the mastoid process of the temporal.

The **third** and smallest **division** is nearest the median line, and is given off from the main mass of the erector above the middle of the thorax. It is called the *spinalis dorsi* (Fig. 410), "the spinal muscle of the back," with reference to its bony attachments. It is a continuation of that portion of the common mass which arises from the lumbar and thoracic spines, and is inserted into the spines of a variable number of vertebræ in the upper thoracic region.

The effect of this arrangement is such that the erection of the vertebral column is accomplished, not as it would be by a muscle which had no attachments between the sacrum and cranium, but by a continuous succession of contractions from one small division of the column to another only a short distance away. Thus, a variety of actions is effected, and strength and steadiness of movement insured.

The nervous supply of the entire series comes through the dorsal primary branches of the spinal nerves.

Muscles in the Fifth Group of the Back.

The *fifth series* of muscles lies in front of the erector spinæ. They are all characterized by the direction of their fibres, which is from below upward and inward. Nearly all of the points of origin are on transverse processes of vertebræ, and most of the insertions are on spinous processes, the fibres passing from a transverse process to the spinous process of the fourth, fifth, or sixth vertebra above. They are the following:

- Complexus.
- Semispinalis cervicis.
- Semispinalis dorsi.
- Multifidus.
- Rotatores.

Complexus (Figs. 413, 411), "the intricate muscle," sometimes is called *semispinalis capitis*, but without good reason; for the term "semispinalis" in connection with other muscles is used to signify that one attachment is upon spinous processes of vertebræ. It arises from the transverse processes of the upper six

or seven thoracic vertebræ and the last cervical, and from the articular processes of cervical vertebræ from the third to the sixth. It is inserted into the occipital bone, on the mesial part of the surface between the curved lines. The portion nearest the middle line is somewhat detached, and has a tendinous inscription about half way of its length, on account of which it is often reckoned as a separate muscle, the *biventer cervicis*. The complexus extends the head, drawing it to one side. Its nerve-supply is from several upper cervical nerves.

FIG. 413.—Trachelo-mastoid and complexus. (Testut.)

Semispinalis cervicis (Fig. 412), the name meaning "the muscle of the neck, one extremity of which is attached to spinous processes," arises from the transverse processes of the upper five or six thoracic vertebræ, and is inserted into the spinous processes of cervical from the second to the fifth. It extends the neck, and rotates it to the opposite side. Its nerves are branches from the lower cervical and upper thoracic.

Semispinalis dorsi (Fig. 412), "the muscle of the back, one end of which is attached to spinous processes," arises from the transverse processes of thoracic vertebræ from the sixth to the tenth, and is inserted into the spinous processes of the last two cervical and of the upper four, five, or six thoracic vertebræ. Its principal action is extension of the lower cervical and upper thoracic regions. It is supplied by thoracic spinal nerves.

Multifidus (Fig. 412), "the many-cleft muscle," occupies the greater part of the gutter beside the vertebral spines from the sacrum to the axis. Its fibres pass from some part (usually a process) of one vertebra to the spinous processes of several vertebræ above it, generally the second, third, and fourth. It arises from the groove on the back of the sacrum, the mammillary processes in the lumbar region, the transverse in the thoracic region, and the articular of the lower four cervical vertebræ, and is inserted into all the spinous processes of the true vertebræ. It extends, bends sidewise, and rotates to the opposite side the spinal column. The posterior branches of the spinal nerves supply it.

Rotatores, rotators of the spine, lie covered in by the multifidus, and are by some regarded as part of it. They are constant only in the thoracic region, are eleven in number, and each passes between the transverse process of one vertebra and the lamina of the next above. They produce rotation of the spine to the opposite side, and also bend it backward and sidewise. Their nerves are the thoracic.

In the cervical and lumbar regions are found a series of small muscles, called *interspinales*, which pass from one spinous process to the next above; and another series, the *intertransversales* (*intertransversarii*), which connect one transverse process with the next above. The former assists in extension of the spine, the latter in its lateral flexion.

SUBOCCIPITAL MUSCLES.

Rectus capitis posterior major.	Obliquus capitis inferior.
Rectus capitis posterior minor.	Obliquus capitis superior.

Rectus Capitis Posterior Major (Fig. 412).—The name means literally "the greater straight hind muscle of the head." It arises from the spine of the axis,

passes upward and outward, and is inserted into the outer part of the inferior curved line of the occipital, and the surface in front of it. It extends the head, and rotates it to the same side. The *suboccipital nerve* supplies it and all the others of this group.

Rectus Capitis Posterior Minor (Fig. 412), "the smaller straight hind muscle of the head," arises on the tubercle of the posterior arch of the atlas, runs upward and outward, and is inserted into the inner part of the inferior curved line of the occipital and the area in front of it. It extends the head.

Obliquus Capitis Inferior (Fig. 412), "the lower oblique muscle of the head," arises from the spine of the axis, goes upward and outward, and is inserted into the transverse process of the atlas. Its principal action is to rotate the atlas to the same side.

Obliquus Capitis Superior (Fig. 412), "the upper oblique muscle of the head," arises from the transverse process of the atlas, passes upward, backward, and inward, and is inserted into the surface behind the inferior curved line of the occipital. It extends the head.

The three-sided space enclosed by the rectus major and the two obliqui is the *suboccipital triangle.*

THE MUSCLES OF THE ABDOMEN.

Rectus abdominis.	Obliquus externus abdominis.	Transversalis.
Pyramidalis.	Obliquus internus abdominis.	Quadratus lumborum.

Of these muscles the rectus and pyramidalis are in front, the quadratus is behind, and the contractile portion of the obliquus externus, obliquus internus, and transversalis are at the side, their fibrous part extending forward and inward to the median line of the belly.

Rectus Abdominis (Fig. 414).—"The straight muscle of the abdomen." *Situation*, in the front wall of the belly. *Origin*, the pubic crest and symphysis, the tendon from the latter point coming from the opposite side and crossing its fellow. *Direction*, upward, curving with convexity forward, corresponding with the contour of the belly. *Insertion*, the fifth, sixth, and seventh costal cartilages. Several tendinous intersections (*inscriptiones tendineæ* or *lineæ transversæ*), usually not occupying the whole thickness of the muscle, cross it, generally one at the level of the ensiform appendix, one at that of the navel, one between these, and often one below. The sheath of the muscle is formed by the tendons of the lateral muscles. (See below.) *Action*, depression of the thorax, and compression of the abdominal viscera. *Nerves*, the lower intercostal and the ilio-hypogastric.

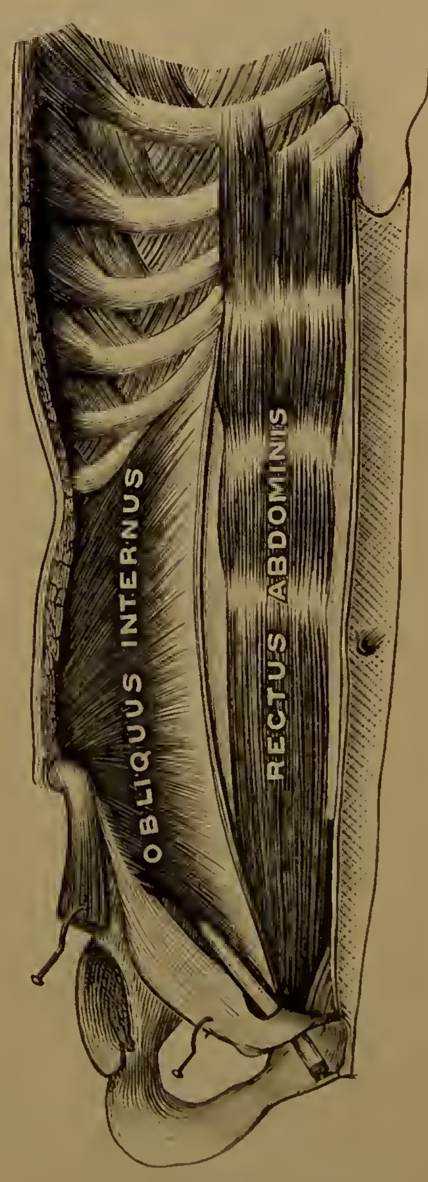

FIG. 414.—Rectus abdominis and obliquus internus of right side. (Testut.)

The three lateral muscles constitute three nearly co-extensive layers, and their broad tendons of insertion (called "aponeuroses"), separate at first, become blended along a slightly curved, nearly vertical line (called *linea semilunaris*, "the half-moon line") just at the outer edge of the rectus. This combined tendon then splits vertically into laminæ of equal thickness, which separate and embrace the rectus, one going in front, the other behind, and finally meet again at the median line, where they fuse with each other and with the corresponding structures of the opposite side, making a strong, perpendicular, fibrous band called *linea alba*, "the white line," which runs from ensiform process above to symphysis pubis below. The inclu-

sion of the rectus by these tendons obtains, however, only in the upper three-fourths of its extent; the tendons all pass in front of the muscle in the lower quarter, leaving the corresponding hind surface free.

Pyramidalis (Fig. 414).—"The pyramidal muscle." It arises from the front of the os pubis, runs up in the sheath of the rectus a short distance, and is inserted into the linea alba. It is very inconstant in presence, size, and shape. It is adjunct to the rectus. Its nerves are the eleventh and twelfth thoracic and the ilio-hypogastric.

Obliquus Externus Abdominis (Fig. 415).—"The external oblique muscle of the abdomen." *Situation*, superficial, in the side and front walls of the belly. *Origin*, the outer surface of the lower eight ribs. *Direction*, downward in the hind part; downward, forward, and inward elsewhere. *Insertion*, the front half of the outer lip of the iliac crest, the pubic spine and crest, the ilio-pectineal line, the front of the symphysis, and the linea alba. The points of origin make a saw-toothed line, the upper digitations interlocking with similar points of the serratus magnus, the lower

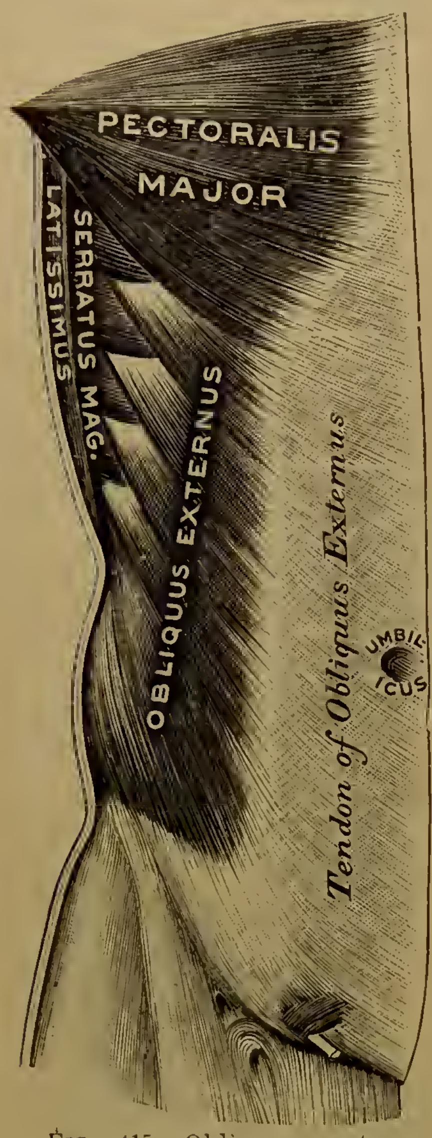

Fig. 415.—Obliquus externus abdominis of right side. (Testut.)

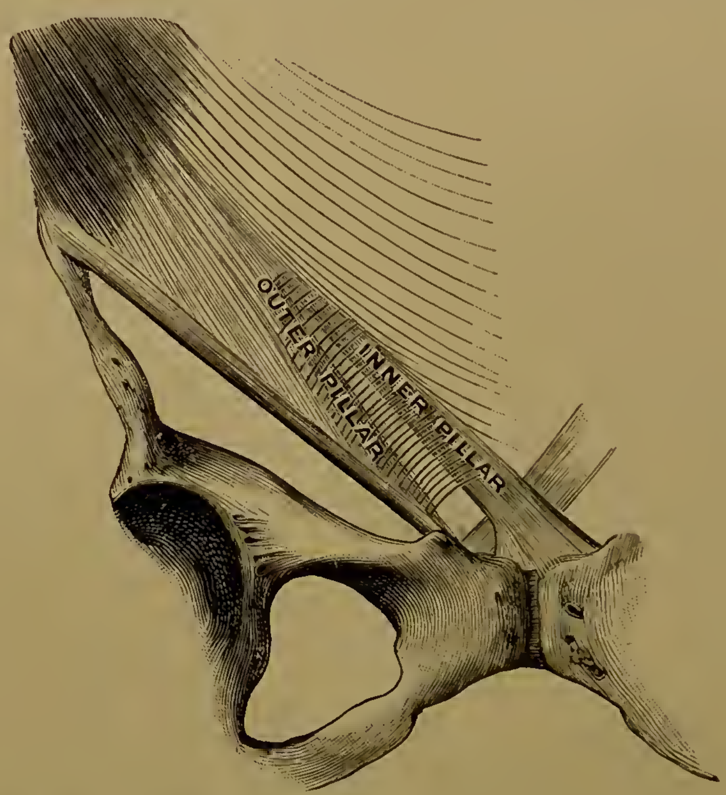

Fig. 416.—External abdominal ring of right side. (Testut.)

with those of the latissimus. The tendon of insertion is a broad sheet, which passes to the mid-line, and there fuses with its fellow opposite and with the tendons of the internal oblique and transversalis. The part of the tendon extending from the anterior superior iliac spine to the pubic spine is thicker than the rest, and its edge is curled backward, forming a narrow shelf. This thick part is the *inguinal ligament*, commonly called Poupart's ligament. From its pubic end extends backward to the neighboring extremity of the ilio-pectineal line a flat, triangular process, having a free, concave outer border, and known as Gimbernat's ligament, or the *lacunar ligament*. From this last a small, fibrous band, the *triangular ligament*, runs upward and inward behind the lower part of the external abdominal ring and its inner pillar, and its fibres mingle with those of its opposite fellow. Just above the pubic body the tendon presents an opening, the *external abdominal ring* (Fig. 416), which results from a separation of the fibres. The aperture slopes upward and outward, and would be triangular were it not for certain fibres, which cross all but the lowest and widest inch of it, and are called *intercolumnar*, because they are *between the pillars*, as the inner (upper) and outer (lower) edges of the tendon, which margin the sides

of the hole, are called. The inner pillar runs to the symphysis and the opposite pubic bone, the right pillar overlapping the left. The outer pillar is attached to the spine of the pubic bone. Thus, the ring is bounded below by the pubic crest, above by the inner pillar, outside by the intercolumnar fibres, and elsewhere by the outer pillar. The ring is occupied by the spermatic cord in the male, by the round ligament of the womb in the female, and is the superficial extremity of the inguinal canal, which will be described after this set of muscles has been considered. From the intercolumnar fibres a thin layer, the *intercolumnar fascia,* is prolonged downward over the cord and testis. *Action,* compression of the abdominal viscera, rotation of the pelvis to the same side, flexion of the pelvis on the chest. *Nerves,* the lower intercostal, the ilio-inguinal, and the ilio-hypogastric.

Obliquus Internus Abdominis (Fig. 414).—"The internal oblique muscle of the abdomen." *Situation,* in the side and front of the belly-wall, next deeper than the external oblique. *Origin,* the outer half of the inguinal ligament, two-thirds of the middle lip of the iliac crest, and, slightly, the lumbar fascia. *Direction,* in general, forward, inward, and upward; also, directly upward behind, and downward in front. *Insertion,* the lower borders of the costal cartilages from the twelfth to the seventh, the ensiform process, the linea alba, the crest of the os pubis, and the ilio-pectineal line. The portion inserted into the pubic bone and ilio-pectineal line enters into the formation of the *conjoined tendon* of the internal oblique and transversalis. The lower portions of the internal oblique give off a series of muscular slips, which are arranged in loops in front of and embracing the spermatic cord. They constitute the *cremaster muscle* ("the supporting muscle"), and the areolar tissue in the spaces between them is the *cremasteric fascia.* The cremaster lifts the testicle. *Action,* the internal oblique compresses the abdominal viscera, depresses the ribs, flexes the chest upon the pelvis, and rotates it to the side on which the muscle acts. *Nerves,* the ilio-hypogastric, ilio-inguinal, and lower intercostals.

Transversalis Abdominis (Fig. 417).—"The transverse muscle of the abdomen." *Synonym,* transversus abdominis. *Situation,* deep in the side and front walls of the belly. *Origin,* the inner surfaces of the lower six costal cartilages, the transverse processes of the lumbar vertebræ, the anterior two-thirds of the inner lip of the iliac crest, and the outer third of the inguinal ligament. *Direction,* forward and inward, and in lowest part downward. *Insertion,* the linea alba and (by the conjoined tendon of this muscle and the internal oblique) the crest of the os pubis and the neighboring part of the ilio-pectineal line. The transversalis at its upper origin interdigitates with the diaphragm. Between its costal and iliac regions its origin is tendinous, and lies between the erector spinæ and quadratus lumborum. This tendon is otherwise known as the middle layer of the lumbar fascia, and extends from the last rib to the ilio-lumbar ligament. *Action,* compression of the abdominal viscera. *Nerves,* the lower intercostal, ilio-hypogastric, and ilio-inguinal. The muscular fibres at the upper third of the transversalis extend toward the middle line so far as to lie behind the rectus.

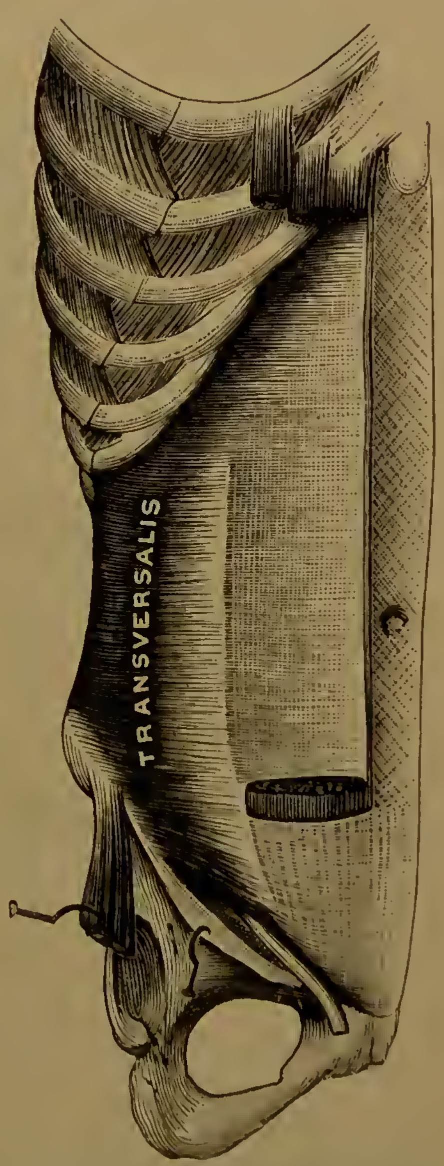

Fig. 417.—Transversalis abdominis of right side. (Testut.)

It is well to note that the three muscles in the side of the abdomen are attached to ribs or costal cartilages above and to iliac crest below, respectively, as follows: the outer muscle to the outer surface and outer lip, the inner muscle to the inner surface and inner lip, the middle muscle to the middle surface (the border) and the middle lip. The obliquity

of the fibres of these muscles to each other contributes greatly to the strength of the abdominal wall, and is a safeguard against hernia.

The *Inguinal Canal* is a crevice between the structures of the abdominal wall in the region of the groin, through which passes the spermatic cord or the round ligament of the uterus, according to the sex of the individual. It is an inch and a half long, extending obliquely downward and toward the middle line from an aperture, called the *internal abdominal ring* in the transversalis fascia, a fibrous layer which lines the deep surface of the transversalis muscle. This ring is on a line midway between the anterior superior iliac spine and the pubic symphysis, and about half an inch above the inguinal ligament. The canal ends at the external abdominal ring in the tendon of the external oblique muscle. Its immediate boundaries are as follows: below, the inguinal ligament and Gimbernat's ligament; above, the arching portion of the internal oblique and transversalis muscles; behind, the transversalis fascia, and the conjoined tendon of the internal oblique and transversalis muscles; in front, the internal oblique in the upper part of the canal, the tendon of the external oblique in the lower and greater part.

Quadratus Lumborum (Fig. 345).—"The square muscle of the loins." *Situation*, in the hind wall of the abdomen. *Origin*, the back part of the inner lip of the iliac crest, the ilio-lumbar ligament, and the transverse processes of several lower lumbar vertebræ. *Direction*, upward. *Insertion*, the last rib and the transverse processes of several upper lumbar vertebræ. *Action*, depression of the last rib and lateral flexion of the spine. *Nerves*, the last thoracic and the upper lumbar.

THE MUSCLES OF THE THORAX.

Diaphragma.	Intercostales interni.	Triangularis sterni.
Intercostales externi.	Levatores costarum.	Subcostales.

Diaphragma (Figs. 418, 419).—"The diaphragm," meaning etymologically

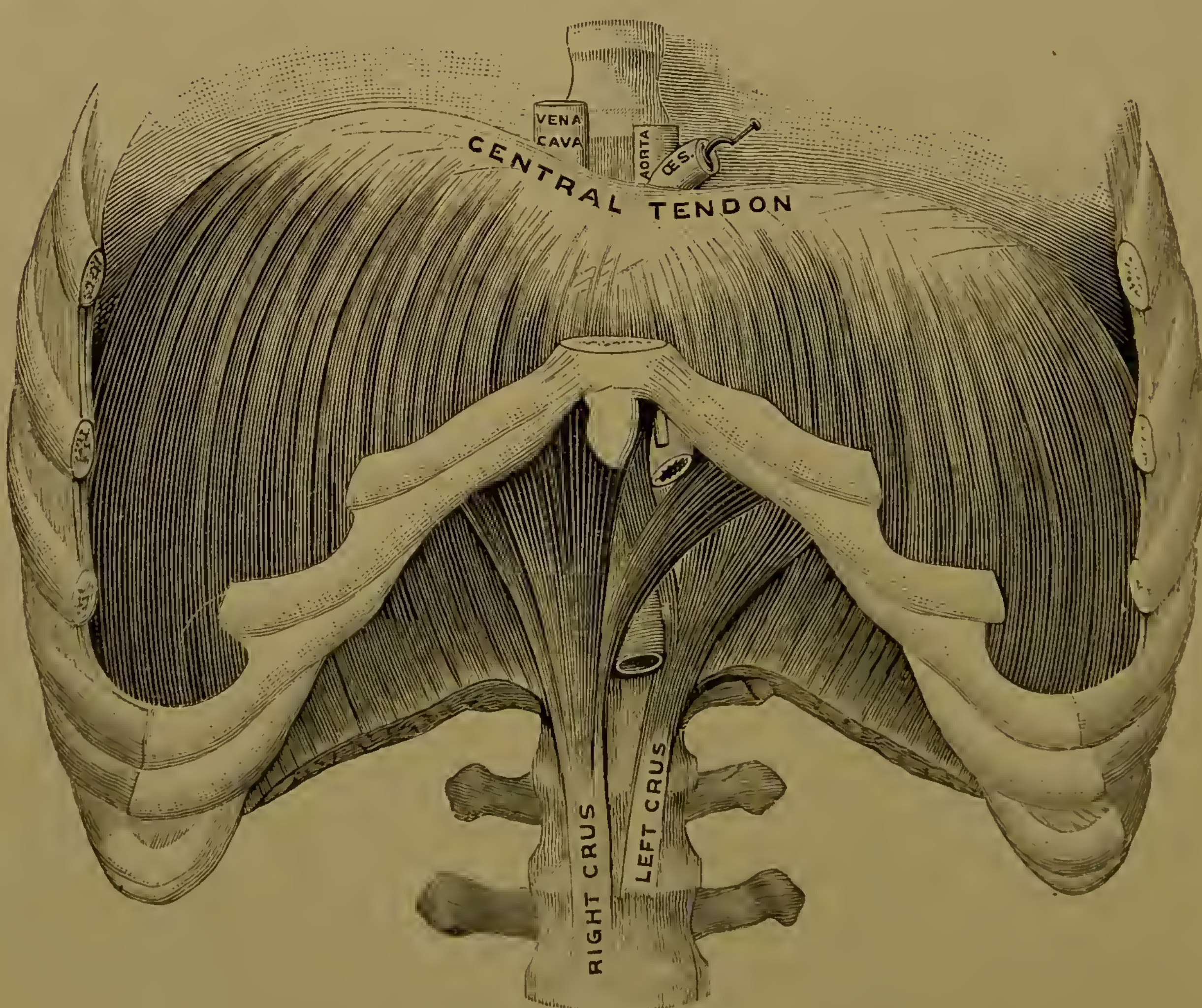

FIG. 418.—Diaphragm, viewed from in front. (Testut.)

"a partition." *Synonym*, the midriff. The diaphragm is the septum between the two great cavities of the trunk, forming the convex floor of the thorax and

the vaulted roof of the abdomen. Its tendon is centrally located, and is, consequently, its highest part; and to this the muscular portion, which is peripheral, rises from its extensive origin at the lower boundaries of the thoracic framework —the sternum, some costal cartilages, several vertebræ, and certain fibrous bands between these vertebræ and the last rib.

From the front of the bodies of the upper two lumbar vertebræ (on the right side one or two more) and the related cartilages rise two processes, called *crura*, which unite and arch over the aorta just below the last thoracic vertebra, the mesial fibres crossing to the opposite side. From the body of the first lumbar vertebra springs a fibrous band, which arches over to the tip of the transverse process, and from this point to the last rib a second band is stretched. The first

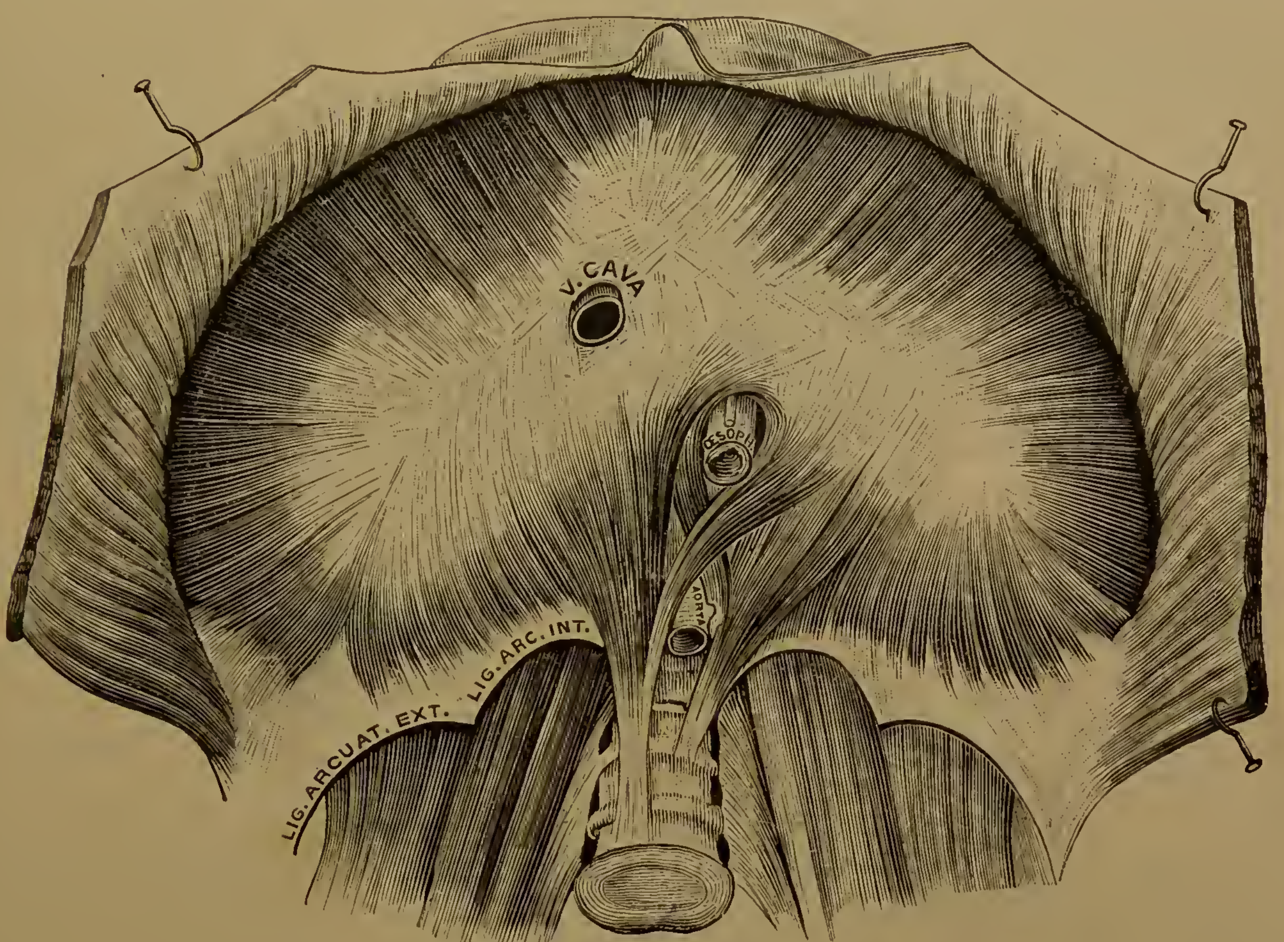

FIG. 419.—Diaphragm, viewed from below. (Testut.)

is called *ligamentum arcuatum internum* ("the inner arched ligament"), and the other, *ligamentum arcuatum externum* ("the outer arched ligament"). Both give origin to muscular fasciculi. The largest part of the diaphragm arises from the inner surface of the last six costal cartilages, interdigitating with the transversalis abdominis. Finally, the ensiform process gives attachment to a small band. The central tendon looks something like a trefoil, is very large, and to it the muscular bundles converge from the entire margin of the muscle.

The aortic opening, already described, gives passage to the aorta, thoracic duct, and large azygos vein. In front of this, higher up and a little to the left, is an opening which transmits the œsophagus and pneumogastric nerves. Still higher and to the right is a third large aperture, devoted to the vena cava. Besides these great perforations are a number of small holes, which transmit nerves and vessels.

The diaphragm is higher on the right side over the liver, and its upper surface is somewhat indented at the front central part, beneath the heart. Its nerve-supply is mainly from the phrenics, slightly from the lower intercostals.

When the diaphragm contracts, its arch is flattened, and thus the vertical capacity of the chest is increased.

Intercostales Externi (Fig. 420).—"The external between-the-ribs muscles," the muscles in the outer layer between the ribs. Their number corresponds to that of the intercostal spaces. They generally extend from the tubercles of the ribs to the junction of the cartilages; the remainder of each space is occupied by

a fibrous membrane. A similar membrane lines the muscles from the angles of the ribs backward. Each muscle arises from the lower border of a rib, runs downward and forward, and is inserted into the upper border of the rib next below. Their action lifts the ribs. Their nerves are the intercostal.

Intercostales Interni (Fig. 420).—"The internal between-the-ribs muscles." Their number is that of the intercostal spaces. They occupy these spaces from the sternum to the angles of the ribs, and beyond these points fibrous membranes fill the spaces. Each muscle arises on the inner surface of a rib and its cartilage, just above its lower border, runs down- and backward, and is inserted into the

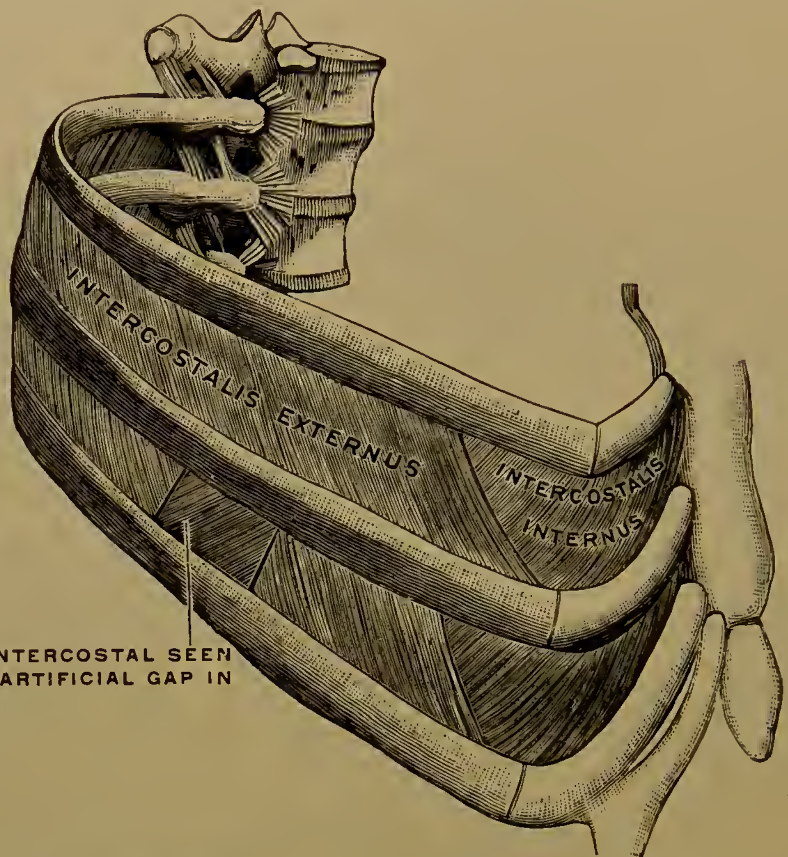

FIG. 420.—Intercostal muscles in right wall of thorax. (Testut.)

inner surface of the rib just beneath. Their action is not agreed upon. The intercostal nerves supply them.

Levatores Costarum (Fig. 411, L. C.).—"The lifters of the ribs." They are twelve in number. Each is inserted into the outer surface of a rib, between its tubercle and angle, and arises from the tip of the transverse process of the vertebra immediately above. A few of those which are lowest in the series have each an insertion also into a rib beyond that proper to itself. The name of these muscles indicates their supposed action—elevation of the ribs; but it is probable that, instead of this, they contribute to the extension and lateral flexion of the thoracic part of the vertebral column. They are supplied by the intercostal nerves.

Triangularis Sterni.—"The triangular muscle of the sternum." *Synonym*, transversus thoracis anterior, "the front transverse muscle of the chest." *Situation*, on the inner side of the thoracic cage in front. *Origin*, the ensiform process, the lower part of the gladiolus, and the cartilages of the lower two or three true ribs. *Direction*, partly horizontal, partly oblique, partly nearly vertical. *Insertion*, the outer extremities of the costal cartilages from the second to the sixth. *Action*, depression of the ribs, to whose cartilages it is attached. *Nerves*, the intercostal.

Subcostales.—"The under-the-ribs muscles." *Synonym*, infracostales, "the beneath-the-ribs muscles." These are small, inconstant muscles, found usually near the angles of the ribs, on the inner surface of these bones, and extending over two intercostal spaces. Their direction is down- and backward, and their nerves, the intercostal. Their action, which must be very insignificant, is not yet determined.

THE MUSCLES OF THE NECK.

A number of the muscles in the neck have already been considered in connection with those of the back, the continuity of tissue or the close functional relation between the former and the latter making this arrangement most convenient in all cases, and inevitable in others.

There remain for study those muscles which are located in the ventral and lateral portions of the neck.

MUSCLES OF THE FRONT AND SIDE OF THE NECK.

Superficial.

Platysma. Sterno-cleido-mastoideus.

Infrahyoid.

Sterno-hyoideus. Sterno-thyroideus.
Omo-hyoideus. Thyro-hyoideus.

Suprahyoid.

Digastricus. Mylo-hyoideus.
Stylo-hyoideus. Genio-hyoideus.

Deep Lateral.

Scalenus anterior. Scalenus posterior.
Scalenus medius. Rectus capitis lateralis.

Prevertebral.

Rectus capitis anterior major. Rectus capitis anterior minor.
Longus colli.

Platysma (Fig. 421).—"The broad sheet muscle." *Synonym,* platysma myoides, "the muscle-like sheet." *Situation,* in the front and side of the neck, and the lower part of the side of the face. *Origin,* the skin and areolar tissue covering the upper part of the pectoralis major and deltoideus, and the clavicular part of the trapezius. *Direction,* upward and inward. *Insertion,* the outer surface of the mandible as far back as the masseter, the muscular structures about the angle of the mouth and the lower lip, and the corresponding parts of the skin. Some fibres cross to the opposite side. *Action,* it draws the angle of the mouth and the lower lip down- and outward, and contracts the skin of the neck. *Nerve,* the facial.

Sterno-cleido-mastoideus (Fig. 422).—"The sternum-clavicle-mastoid-process muscle." *Synonym,* sterno-mastoideus. *Situation,* in the side of the neck. *Origin,* the front of the manubrium and inner third of the clavicle. *Direction,* upward and backward. *Insertion,* the mastoid process of the temporal, and the outer half of the superior curved line of the occipital. An interval exists between the sternal and clavicular origins. The muscle divides the lateral area of the neck into two triangles. *Action*: it draws the head toward the shoulder, and rotates the face toward the opposite side. When the two muscles act, the head is extended. *Nerves,* the spinal accessory and second cervical.

Sterno-hyoideus (Fig. 423).—"The sternum-hyoid-bone muscle." *Situation,* in the front of the neck. *Origin,* the back of the manubrium, and inner end of the clavicle. *Direction,* upward. *Insertion,* the body of the hyoid. *Action,* depression of the hyoid. *Nerve,* the ansa hypoglossi.

Omo-hyoideus (Figs. 422, 423).—"The shoulder-hyoid-bone muscle." *Situation,* the upper part of the shoulder and the front of the neck. *Origin,* the scapula, near the suprascapular notch. *Direction,* forward and inward to behind

the sterno-cleido-mastoid, and then upward and a little inward. *Insertion*, the body of the hyoid. This is a slender, double-bellied muscle. The middle tendon is held down by a loop of deep fascia, which is attached below to the sternum and cartilage of the first rib. *Action*, depression of the hyoid. *Nerve*, the descendens hypoglossi and ansa hypoglossi.

Sterno-thyroideus (Fig. 423).—"The sternum-thyroid-cartilage muscle." *Situation*, the front of the neck, behind the sterno-hyoid. *Origin*, the back of the manubrium, and cartilage of the first rib. *Direction*, upward. *Insertion*, the oblique line on the ala of the thyroid cartilage. *Action*, depression of the thyroid cartilage. *Nerve*, the ansa hypoglossi.

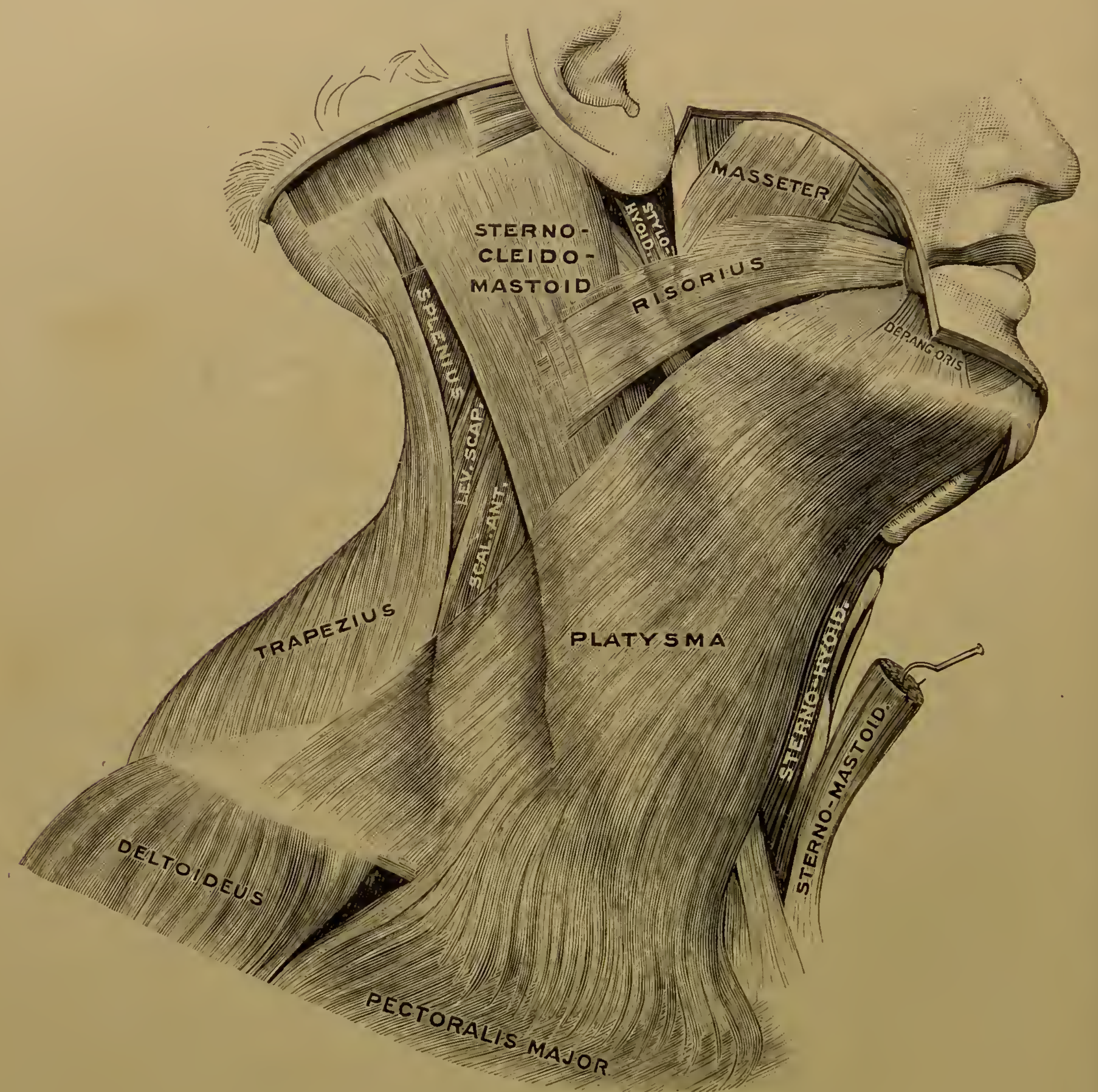

FIG. 421.—Superficial muscles of side of neck. (Testut.)

Thyro-hyoideus (Fig. 423).—"The thyroid-cartilage-hyoid-bone muscle." *Situation*, in the front of the neck. *Origin*, the oblique line on the ala of the thyroid cartilage. *Direction*, upward. *Insertion*, the body and great cornu of the hyoid. *Action*, depression of the hyoid; by reversed action, elevation of the thyroid cartilage. *Nerve*, the hypoglossal.

Digastricus (Figs. 422, 423).—"The two-bellied muscle." *Situation*, the uppermost part of the side of the neck. *Origin*, the digastric fossa of the temporal. *Direction*, forward, inward, and downward, then forward, upward, and slightly inward. *Insertion*, the mandible, at its lower border near the symphysis. The tendon between the bellies is held down to the hyoid bone by a fibrous loop and the stylo-hyoid muscle, and the change in direction is effected at this point.

Action, elevation of the hyoid, if the mandible is fixed; depression of the mandible, if the hyoid is fixed. *Nerves,* the facial for the hind belly, the inferior maxillary division of the trifacial for the front belly.

Stylo-hyoideus (Fig. 422).—"The styloid-process-hyoid-bone muscle." *Situation,* in the uppermost part of the side of the neck, along the upper border of the hind belly of the digastricus. *Origin,* the root of the styloid process of the temporal. *Direction,* down- and forward. *Insertion,* the hyoid. Near its insertion it is perforated by the digastricus. *Action:* it lifts the hyoid, and pulls it backward and sidewise. *Nerve,* the facial.

Mylo-hyoideus (Fig. 422).—"The molar-teeth-hyoid-bone muscle," so-called

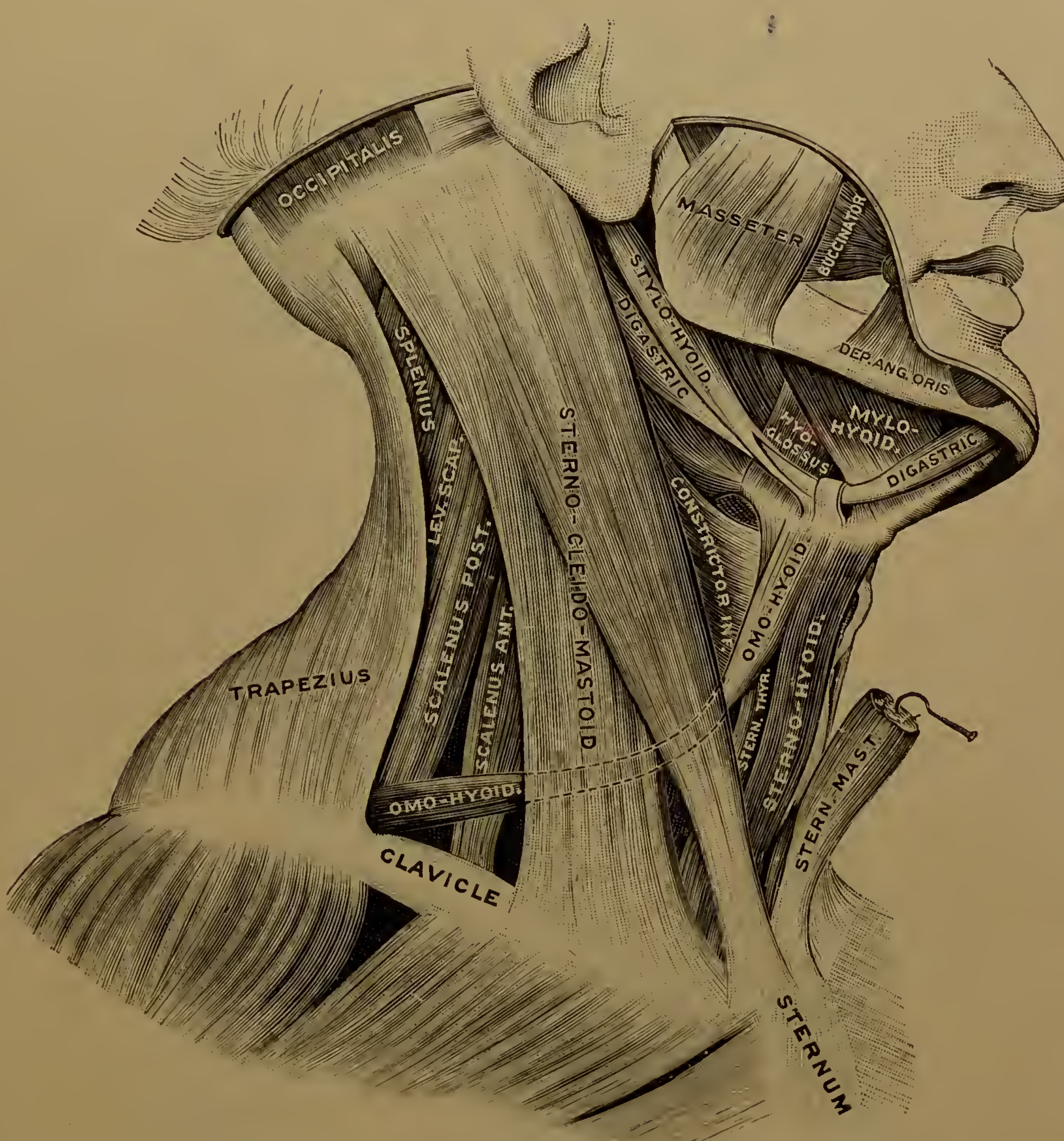

FIG. 422.—Muscles in front and side of neck. (Testut.)

from its attachments near the molars of the lower jaw and to the hyoid bone. *Situation,* in the floor of the mouth. *Origin,* the mylo-hyoid ridge of the mandible. *Direction,* inward and downward. *Insertion,* behind to the body of the hyoid, in the middle line to its fellow opposite. *Action,* it lifts and advances the hyoid and the floor of the mouth. *Nerve,* the mandibular division of the trifacial.

Genio-hyoideus (Fig. 423).—"The chin-hyoid-bone muscle." *Situation,* in the floor of the mouth, above the mylo-hyoideus. *Origin,* the lower genial tubercle. *Direction,* backward and a little downward. *Insertion,* the body of the hyoid. *Action:* it lifts and advances the hyoid. *Nerve,* the hypoglossal.

Scalenus Anterior (Fig. 424).—"The front scalene muscle"—*i. e.,* triangular with unequal sides. *Situation,* deep in the side of the neck. *Origin,* the anterior

tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ. *Direction*, down-, out-, and forward. *Insertion*, the tubercle on the upper surface of the first rib. *Action*, elevation of the first rib. *Nerves*, the neighboring cervical.

Scalenus Medius (Fig. 424).—"The middle scalene muscle." *Situation*, deep in the side of the neck. *Origin*, the posterior tubercles of the transverse processes of all of the cervical vertebræ. *Direction*, down-, out-, and forward. *Insertion*, the upper surface of the first rib. *Action*, elevation of the first rib. *Nerves*, the neighboring cervical.

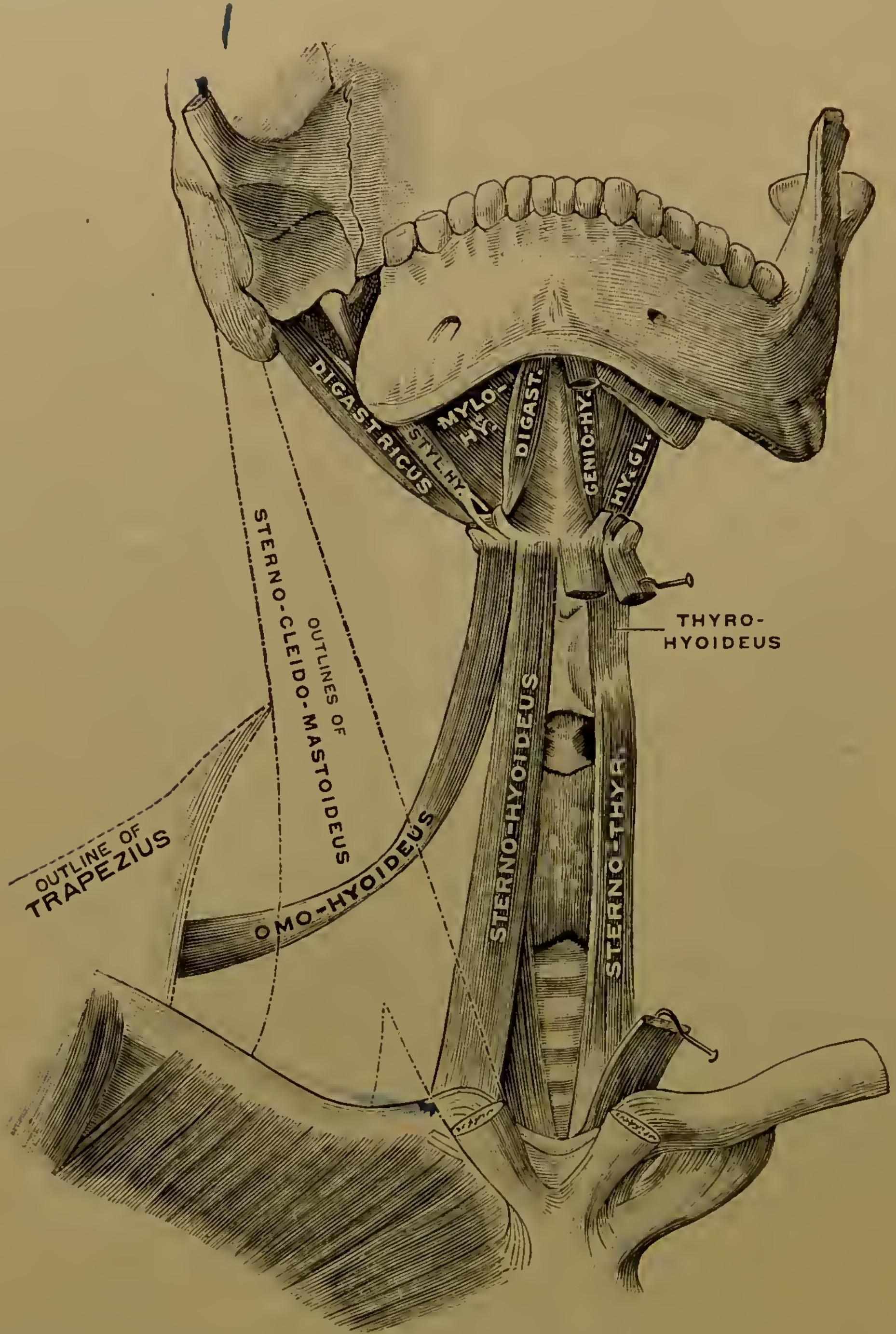

FIG. 423.—Infrahyoid and suprahyoid groups of muscles. (Testut.)

Scalenus Posterior (Fig. 424).—"The hind scalene muscle." *Situation*, deep in the side of the neck. *Origin*, the posterior tubercles of the transverse processes of the lower two or three cervical vertebræ. *Direction*, down-, out-, and forward. *Insertion*, the outer surface of the second rib in front of the angle. *Action*, elevation of the second rib. *Nerves*, the neighboring cervical.

Rectus Capitis Lateralis (Fig. 424).—"The side straight muscle of the head." *Situation*, the side of the highest part of the neck. *Origin*, the transverse process of the atlas. *Direction*, upward. *Insertion*, the jugular process of the occipital. *Action*, tilting the head sidewise. *Nerve*, the first cervical.

Rectus Capitis Anterior Major (Fig. 424).—"The greater front straight muscle of the head." *Synonym*, rectus capitis anticus major. *Situation*, in front of the upper cervical vertebræ. *Origin*, the anterior tubercles of the transverse

processes of the third, fourth, fifth, and sixth cervical vertebræ. *Direction*, up- and inward. *Insertion*, the basilar process of the occipital. *Action*, flexion of the head on the spine. *Nerves*, the first and second cervical.

Rectus Capitis Anterior Minor (Fig. 424).—"The smaller front straight muscle of the head." *Synonym*, rectus capitis anticus minor. *Situation*, between the atlas and occipital bone in front. *Origin*, the front of the transverse process of the atlas. *Direction*, up- and inward. *Insertion*, the basilar process of the occipital. *Action*, flexion of the head. *Nerves*, the first cervical.

Longus Colli (Fig. 424).—"The long muscle of the neck." *Situation*, in front of the cervical and upper thoracic vertebræ. *Division*, into three parts: the vertical or middle, the lower oblique, and the upper oblique. The *vertical part* arises from the bodies of the last two cervical and two or three thoracic vertebræ, and the transverse processes of the last three or four cervical, and is inserted into the bodies of the second, third, and fourth cervical. The *lower oblique part* arises from the bodies of the upper two or three thoracic vertebræ, and is inserted

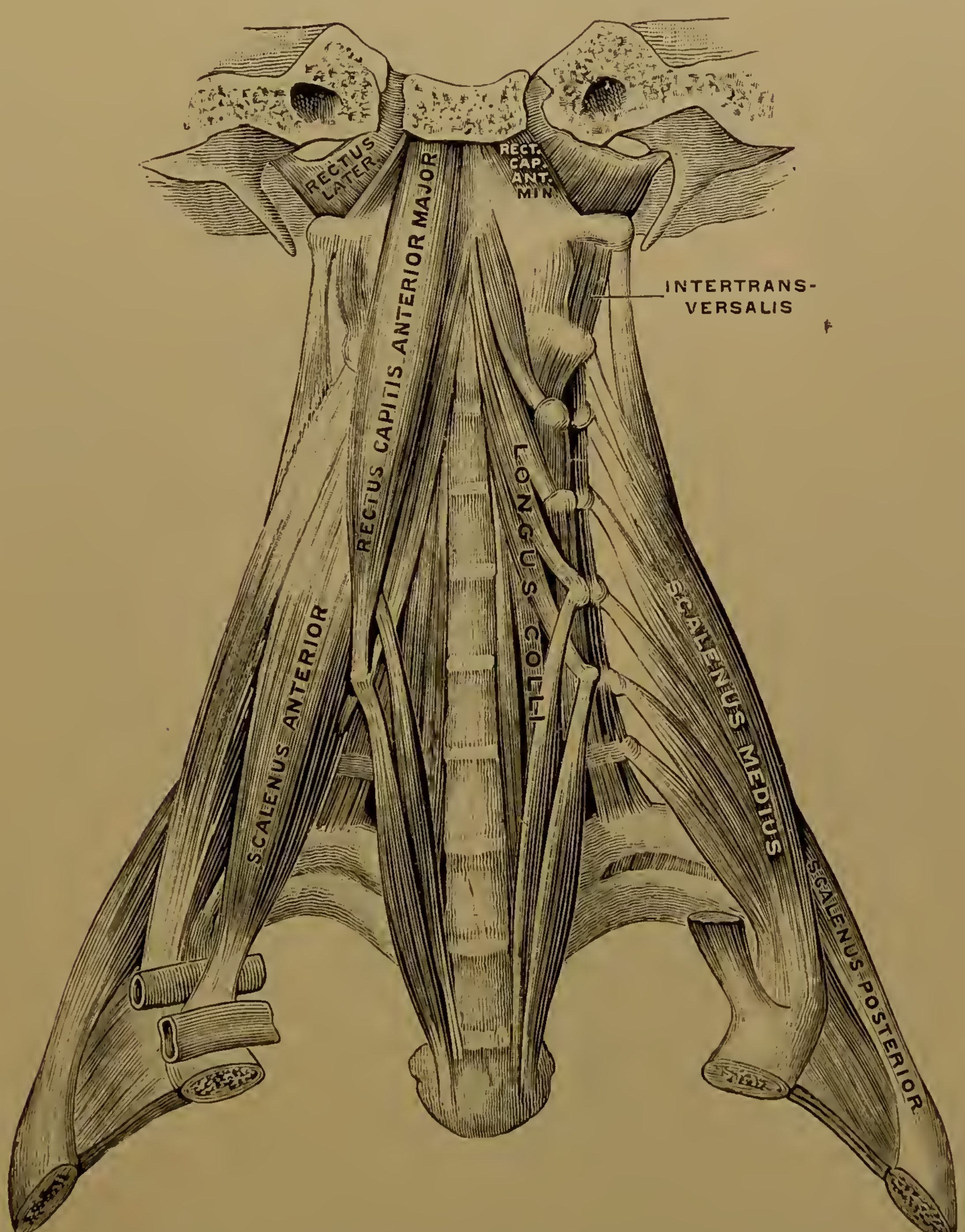

FIG. 424.—Deep lateral and prevertebral muscles of the neck. (Testut.)

into the anterior tubercles of the transverse processes of the fifth and sixth cervical. The *upper oblique part* arises from the anterior tubercles of the transverse processes of the third, fourth, and fifth cervical vertebræ, and is inserted into the anterior tubercle of the atlas. *Action*, mostly, flexion of the neck; also, rotation. *Nerves*, the neighboring cervical.

THE MUSCLES OF THE HEAD.

In the head are many muscles which are most conveniently treated of in connection with certain special organs, as the tongue, palate, pharynx, eye, and ear. In this place, therefore, there will be considered only the superficial muscles.

SUPERFICIAL MUSCLES OF THE HEAD.

Muscles of Mastication.

Masseter.
Temporalis.
Pterygoideus internus.
Pterygoideus externus.

Muscles of Expression.

1. *Muscles Affecting the Orifice of the Mouth.*

Orbicularis oris.
Levator labii superioris alæque nasi.
Levator labii superioris proprius.
Zygomaticus minor.
Zygomaticus major.
Levator anguli oris.
Risorius.
Buccinator.
Depressor anguli oris.
Depressor labii inferioris.
Levator labii inferioris.

2. *Muscles of the Nose.*

Pyramidalis nasi.
Compressor naris.
Levator labii superioris alæque nasi.
Depressor alæ nasi.

3. *Muscles of the Lids.*

Orbicularis palpebrarum.
Tensor tarsi.
Levator palpebræ.

4. *Muscles of the Forehead.*

Corrugator supercilii.
Frontalis.

5. *Muscle of the Occiput.*

Occipitalis.

The Muscles of Mastication.

Masseter (Figs. 427, 422).—"The chewing-muscle." *Situation,* in the back part of the side of the face. It consists of two portions, the superficial and the deep, which blend at their insertion. The *superficial portion* arises from the lower margin of the anterior two-thirds of the zygoma, passes down- and backward, and is inserted on the outside of the lower half of the ramus of the mandible. The *deep portion* arises from the entire inner surface and the hind third of the lower border of the zygoma, passes downward, and is inserted into the upper half of the ramus of the mandible. *Action,* it lifts the lower jaw and draws it slightly forward. *Nerve,* the mandibular division of the trifacial.

Temporalis (Fig. 425).—"The temple muscle." *Situation,* in the temporal fossa. *Origin,* the entire temporal fossa, except the anterior wall. *Direction,* downward. *Insertion,* the coronoid process of the mandible. *Action,* elevation of the lower jaw, and, when this has been drawn forward, its retraction. *Nerve,* the mandibular division of the trifacial.

Pterygoideus Internus (Fig. 426).—"The internal pterygoid muscle," so called from its position and origin. *Synonym,* the internal masseter. *Situation,* the inner side of the ramus of the mandible. *Origin,* the inner surface of the external pterygoid plate of the sphenoid, and the tuberosities of the palate and superior

maxillary bones. *Direction,* down-, back-, and outward. *Insertion,* the inner side of the ramus of the mandible, between the angle and the dental foramen. *Action,* elevation of the lower jaw. When the jaw is closed, the muscle draws it forward. *Nerve,* the mandibular division of the trifacial.

Pterygoideus Externus (Fig. 426).—"The external pterygoid muscle," named from its position and origin. *Situation,* in the zygomatic fossa. *Origin,* by two

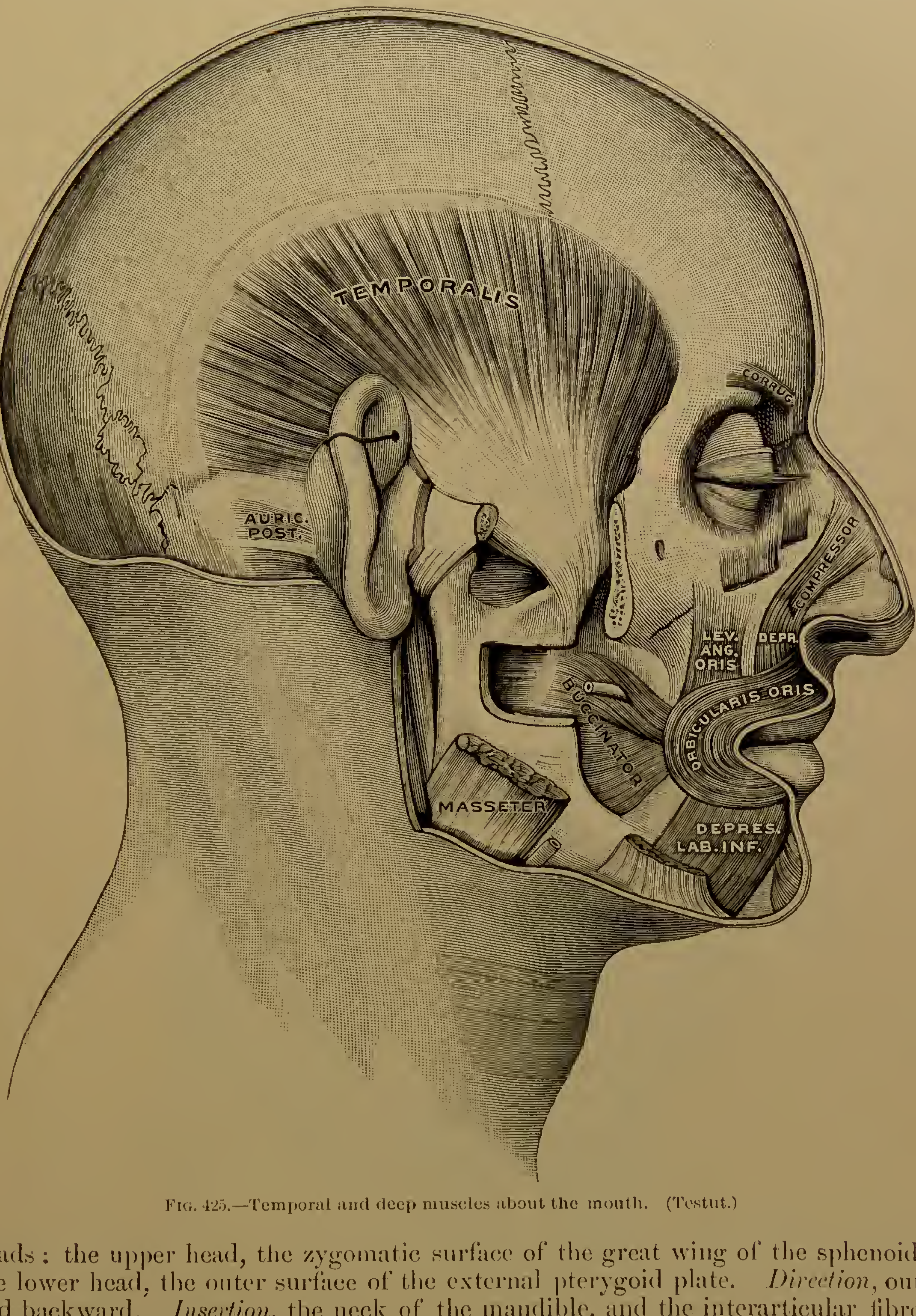

FIG. 425.—Temporal and deep muscles about the mouth. (Testut.)

heads: the upper head, the zygomatic surface of the great wing of the sphenoid; the lower head, the outer surface of the external pterygoid plate. *Direction,* out- and backward. *Insertion,* the neck of the mandible, and the interarticular fibrocartilage of the temporo-mandibular joint. *Action,* it draws the condyle of the mandible and the interarticular cartilage forward and inward. *Nerve,* the mandibular division of the trifacial.

By the succession and combination of the actions of the preceding four muscles the food placed between the teeth is cut into pieces by the incisors, held and torn by the canines, and crushed and ground to a pulp by the molars.

The Muscles of Expression.

The muscles of expression are sometimes called "the mind muscles," from the indications which they may afford of the mental state of the individual. The majority of them are small, often poorly defined, and so blended with each other and the skin that their dissection is frequently difficult and unsatisfactory. They are all supplied by the *facial nerve*. It is helpful to group them according to their situation into those related to the orifice of the mouth, those of the nose, those of the eyelids, those of the forehead, and that of the occiput. Besides these are others, which, in a secondary though important way, contribute to expression. The muscles which move the eyes are very effective in betraying emotion, and the muscular tongue, usually concealed in the oral cavity, may, either with or without partial protrusion from its retreat, be made to convey as distinct an idea as can be given by articulate speech. Even the muscles of the pinna might, without unwarrantable stretch of terms, be included in this group, since they are

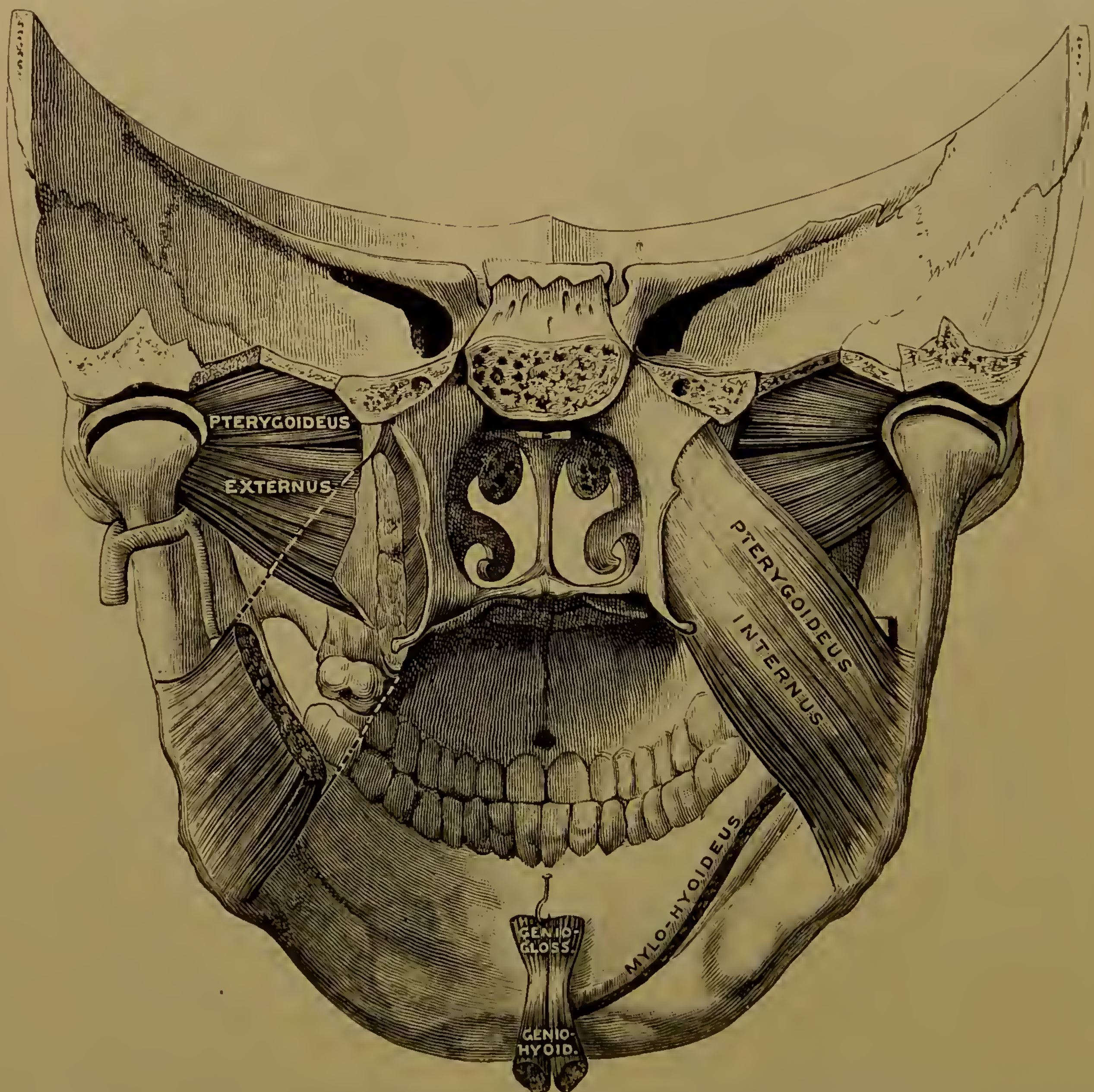

FIG. 126.—Pterygoid muscles, viewed from behind, the back portion of the skull having been removed. (Testut.)

the rudimentary homologues of organs, which, in many lower animals, are strikingly useful in expressing various feelings. But the muscles of the orbit and of the external ear are treated more appropriately in connection with the organs of the special senses; and those of the tongue are best presented, in company with the palatal and pharyngeal, as parts of the alimentary system, just as the laryn-

geal are discussed most conveniently with the respiratory system, and the perineal with the generative system.

MUSCLES AFFECTING THE ORIFICE OF THE MOUTH.

Orbicularis oris.	Levator anguli oris.
Levator labii superioris alæque nasi.	Risorius.
Levator labii superioris proprius.	Buccinator.
Zygomaticus minor.	Depressor anguli oris.
Zygomaticus major.	Depressor labii inferioris.
	Levator labii inferioris.

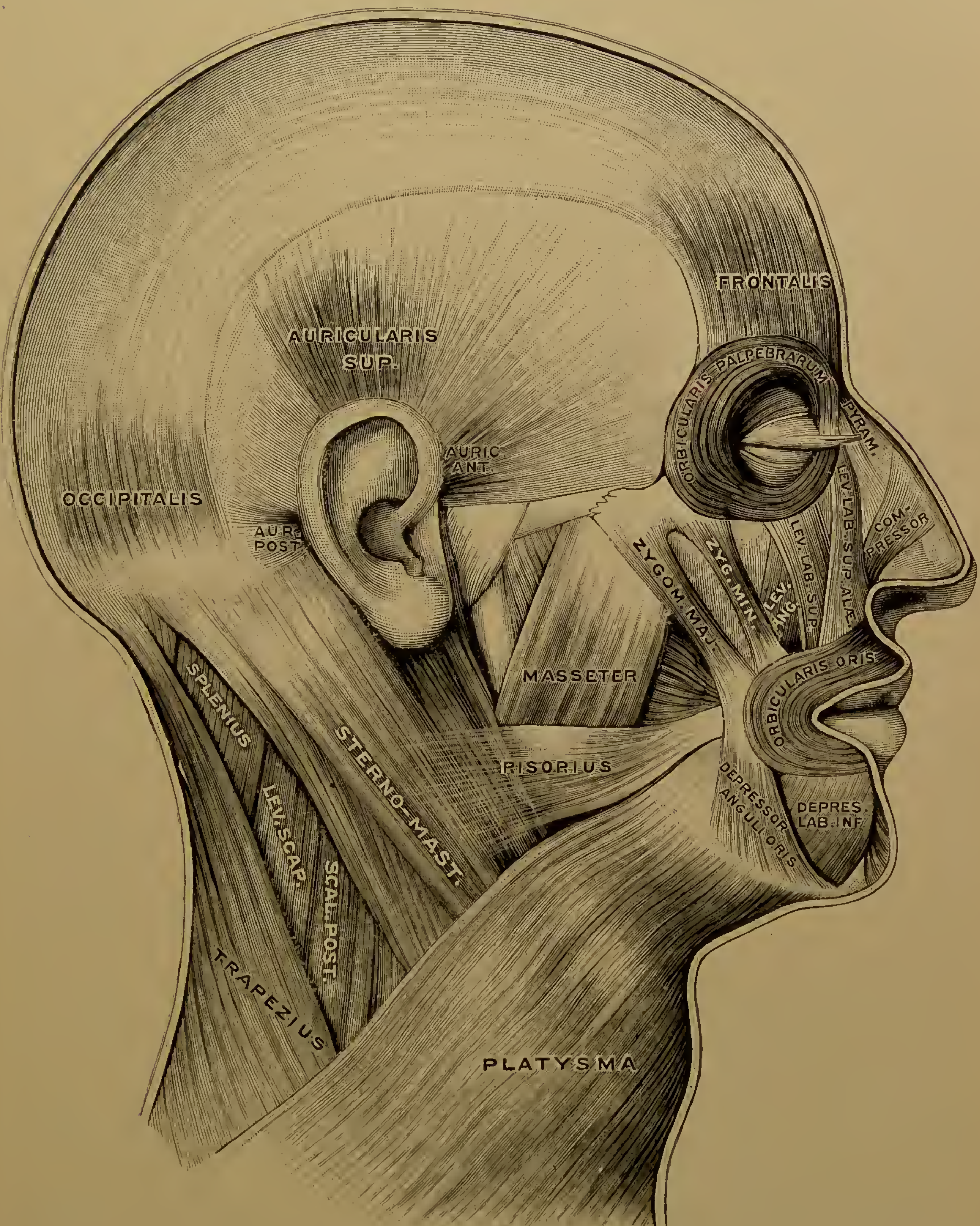

FIG. 427.—Superficial muscles of head and neck. (Testut.)

Orbicularis Oris (Fig. 427).—"The orbicular muscle of the mouth"—that is, encircling the oral orifice. Surrounding the opening of the mouth, and extending from the nose above to the chin below, is an elliptical muscle, which forms a great

part of the bulk of the lips, and constitutes a sphincter to the aperture. It does not, however, consist of concentric bundles of fibres, but is made up very largely of prolongations from various muscles of the face, which converge to its margin. It is attached above to the partition between the nostrils and to the incisor fossæ of the upper jaw-bones, and below to the incisor fossæ of the mandible. It is covered in front by skin, behind and on its free border by mucous membrane. The action of this muscle is to close the lips and press them against the teeth. It antagonizes all of the remaining members of this group, except the levator labii inferioris.

The nine following muscles arise from structures, principally osseous, in the face, converge to the margin of the orbicularis, and are inserted either into it or the skin covering it. Six are close to the surface, and three are more deeply situated. All of them by their action oppose that of the orbicularis, and in various directions enlarge the opening of the mouth.

Levator labii superioris alæque nasi (Fig. 427), "the lifter of the upper lip and of the wing of the nose," arises from the nasal process of the superior maxillary bone, passes downward and outward, and is inserted partly into the wing of the nose, partly into the orbicularis. Its name describes its action.

Levator labii superioris proprius (Fig. 427), "the proper lifter of the upper lip," the last word of the name being used to emphasize the distinction between this and the preceding muscle, which does other than the special work of this. It arises just above the infra-orbital foramen and the neighboring part of the malar bone, runs downward and inward, and is inserted into the margin of the orbicularis and the skin of the lip. It raises the part of the lip near the median line.

Zygomaticus minor (Fig. 427), "the smaller zygomatic muscle." The name implies attachment to the zygoma, but was unwisely given on account of its nearness to a muscle which somewhat merits the title zygomatic. It arises from the front and lower part of the malar bone, and is inserted into the orbicularis and the skin, just outside of the levator labii superioris proprius. It raises and draws outward the upper lip.

Zygomaticus major (Fig. 427), "the larger zygomatic muscle," arises from the malar near its zygomatic suture, passes downward and inward, and is inserted into the skin at the angle of the mouth. It draws the angle upward and outward.

Levator anguli oris (Fig. 425), "the lifter of the angle of the mouth," arises below the infra-orbital foramen, passes downward, and is inserted into the orbicularis and the skin near the corner of the mouth. Its name implies its action.

Risorius (Figs. 421, 427).—The name means "the laughing muscle," but it is not descriptive. The muscle extends from the fascia over the masseter to the skin and orbicularis at the angle of the mouth. It is regarded as a specialized part of the platysma. It draws the mouth outward horizontally, widening the cleft.

Buccinator (Fig. 425), "the trumpeter's muscle," arises from the back part of the outer surface of the alveolar processes of both jaw-bones, and from the pterygo-mandibular ligament. Its different parts converge to the angle of the mouth, and there blend with the orbicularis. It pulls the angle outward, and compresses the contents of the vestibule of the mouth. If the cheek bulges with air, the buccinator presses it out, measurably regulating its expulsion, as in blowing a horn (hence the name); and it keeps the mass of food during mastication from escaping outward from the grasp of the molar teeth.

The *pterygomandibular ligament* is a fibrous band, which connects the hamular process of the sphenoid with the hind end of the internal oblique line of the mandible. It may be regarded as a tendinous inscription between the buccinator and the superior constrictor of the pharynx.

Depressor Anguli Oris (Fig. 427).—"The depressor of the angle of the mouth." *Synonym*, triangularis menti, "the triangular muscle of the chin." It arises from

the external oblique line of the mandible, passes upward, converging to the angle of the mouth, where it blends with the orbicularis. It pulls down the corner of the mouth.

Depressor Labii Inferioris (Figs. 425, 427).—"The depressor of the lower lip." *Synonym,* quadratus menti, "the square muscle of the chin." It arises from the mandible, from near the symphysis to beyond the mental foramen, passes upward and inward, and merges with the orbicularis. It draws the lower lip downward and slightly outward.

Levator Labii Inferioris.—"The lifter of the lower lip." *Synonym,* levator menti, "the lifter of the chin." It arises from the incisor fossa of the mandible, passes downward, and is inserted into the skin of the chin. It differs from the other muscles which act upon the oral aperture in not participating in the structure of the lips or cheeks, and in not antagonizing the orbicularis; but, while its force is primarily directed to the chin, which it elevates, its practical effect is to lift the lower lip, which is carried upward by the movement of the chin, and made to protrude. Thus, it assists the lower half of the orbicularis, helping to close the opening and hold it tightly.

In the play of the features which the muscles about the mouth produce they almost always act in pairs, and one pair rarely acts alone. This is illustrated in the display of the opposite emotions of mirth and grief. In the former the lifters of the angles and the zygomatics draw the corners upward and outward, the risorii widen the aperture still more, and the lifters of the upper lip pull it upward. In the latter the depressors of the angles drag downward the corners of the mouth, the risorii widen the slit, and the lifters of the upper lip draw it upward. In both of these cases it will be observed that the transverse crevice of the mouth is widened, the upper lip is elevated, uncovering the front upper teeth, and the angles of the mouth are drawn outward. By this procedure the cheeks are pulled upward, and a bulging forward of the structures under the orbits and a partial closure of the lower lids are thus produced. The main difference, then, between the facial manifestation of joy and that of sorrow consists in the up-and-down movements of the angles of the mouth. The risorius does not deserve the name of the laughing muscle as well as does the zygomaticus major.

Muscles of the Nose.

Pyramidalis nasi.
Compressor naris.
Levator labii superioris alæque nasi.
Depressor alæ nasi.

Pyramidalis nasi (Fig. 427), "the pyramidal muscle of the nose," arises at the lower border of the nasal bone, passes upward, is inserted into the skin between the brows, and by its action draws this skin downward, producing a horizontal wrinkle. The fibres often seem to be continuous with the median portion of the frontalis.

Compressor Naris (Figs. 425, 427).—"The compressor of the nostril." *Synonyms,* compressor narium, "the compressor of the nostrils;" compressor nasi, "the compressor of the nose." It arises from the nasal bone and adjacent cartilage near the mid-line, passes downward and backward, and is inserted partly into the superior maxillary near the nasal opening, and partly into the levator labii superioris alæque nasi. It pulls inward the muscle to which it is attached, thus wrinkling the nose vertically; and it slightly compresses the nose.

Levator labii superioris alæque nasi has been described on page 360.

Depressor alæ nasi (Fig. 425), "the depressor of the wing of the nose," arises from the incisor fossa of the superior maxillary bone, passes upward and outward, and is inserted into the cartilage of the wing of the nose and into the septum. It draws the wing of the nose downward and inward.

Besides these muscles there are sometimes found two minute and indistinct bundles, which descend to the margin of the ala from the cartilages just above,

and have been dignified by names which are descriptive of their slight action. They are *levator proprius alæ nasi anterior*, "the front proper lifter of the wing of the nose," otherwise called *dilatator naris anterior*, "the front widener of the nostril; and *levator proprius alæ nasi posterior*, "the hind proper lifter of the wing of the nose," sometimes known as *dilatator naris posterior*, "the hind widener of the nostril." Finally, running from the cartilage of the wing to the skin at the tip of the nose is the inconstant and insignificant *compressor narium minor*, "the smaller compressor of the nostrils."

Muscles of the Lids.

Orbicularis Palpebrarum (Fig. 427).—"The circular muscle of the lids." It is situated on the front surface of the tarsi and around the circumference of the orbit. The *palpebral* (tarsal) *ligaments*, which attach the tarsi to the orbital margin, are two in number, and serve as tendons to this muscle. The internal ligament, called also *tendo oculi*, is the larger, and starts from the nasal process of the maxilla. It bifurcates at its outer end, where it is fused with the inner extremity of the tarsi. The external ligament is attached to the frontal process of the malar bone, and its inner end is blended with the outer extremity of the tarsi.

The muscle consists of two continuous portions, the palpebral and the orbital. The *palpebral portion*, spread in a thin sheet over the tarsi, arises from the internal palpebral ligament, a part of its fibres arching upward and a part curving downward, and is inserted mostly into the external palpebral ligament; but a number of its fibres near the palpebral aperture end at the free edge of the tarsi. The *orbital portion*, much the broader and thicker, arises from the internal angular process of the frontal bone, the nasal process of the maxilla, and the internal palpebral ligament. Its fibres are arranged in concentric loops, which sweep around the margin of the orbit, and return to their points of origin. Its margin extends into the region of the forehead, temple, and cheek, blending with adjacent muscles.

Action.—The palpebral portion performs the act of gently closing the lids, as in the involuntary winking, which occurs thousands of times daily. The orbital portion closes the palpebral aperture forcibly, drawing the parts toward the inner angle, and causing thickening of the brow. Both portions together press upon the ball, and protect it from injury in violent straining movements.

Tensor Tarsi, "the tightener of the tarsus," is situated at the mesial side of the orbit, and is continuous with the palpebral portion of the orbicularis. It arises from the lachrymal crest, passes outward, bifurcates, and is inserted into the inner extremity of the tarsi near the puncta lachrymalia. It compresses the lachrymal sac.

Levator Palpebræ will be described with the eyeball-muscles.

Muscles of the Forehead.

Corrugator supercilii.	Frontalis.

Corrugator supercilii, "the wrinkler of the brow," arises from the superciliary ridge, passes outward and upward, and is inserted into the skin above the middle of the upper margin of the orbit. It draws the skin toward the middle line, causing vertical wrinkles in the central lower part of the forehead.

From the brows to the superior curved lines of the occipital bone the vault of the skull is covered by a musculo-membranous structure, which is by some anatomists regarded as a digastric muscle, the *occipito-frontalis*; but the contractile portions will here be described as separate organs, one as a muscle of the forehead, the other as a muscle of the occiput; and the intervening membrane as the epicranial aponeurosis. It will be well to consider the last before the others.

The *epicranial aponeurosis* is a wide, firm, fibrous sheet, running antero-posteriorly over the summit of the cranium, attached before to the frontalis muscle,

behind to the occipitalis and the occipital protuberance. It is thickest near the middle, and very thin at the sides. It is closely adherent to the skin which covers it, but only loosely to the pericranium over which it lies.

Frontalis (Fig. 427), "the forehead muscle," arises from the anterior end of the epicranial aponeurosis, passes downward, and is inserted into the skin and muscles from the root of the nose to the outer end of the eyebrow. It elevates the brows, causing transverse wrinkling of the forehead.

Muscle of the Occiput.

Occipitalis (Fig. 427), "the occipital muscle," is situated at the back of the head. It arises from the outer two-thirds of the superior curved line of the occipital bone and the mastoid portion of the temporal, passes upward, and is inserted into the epicranial aponeurosis. It acts in direct line with the frontalis, and emphasizes its action—that is, the transverse wrinkles of the forehead caused by the frontalis are made more conspicuous when the occipitalis acts at the same time. Alternate contraction of these two muscles in some persons produces a fore-and-aft movement of the scalp. The occipitalis is a weak muscle, but what force it has is exerted in the direction of expression.

THE FASCIÆ.

By F. H. Gerrish.

The word *fascia*, meaning literally a "band" or "bandage," is applied to fibrous, membranous expansions of greater or less density, which are wrapped around various organs, most conspicuously muscles, and serve to keep them in definite and intimate relation with one another. The term is also used to designate certain strong, fibrous sheets which are stretched between bony parts.

Fasciæ are conventionally divided into two groups or varieties—the superficial and the deep. These terms, however, convey very little useful information about the organs to which they are applied. Some members of each group are structurally indistinguishable from typical specimens of the other. The ground of distinction upon which the names are based is their situation; but one variety will frequently be found to shade off by almost imperceptible gradations into the other, even on the same plane. In their typical forms, however, the superficial fascia is a loose, extensible structure; the deep fascia is firm, strong, and inextensible.

THE SUPERFICIAL FASCIA.

Immediately beneath the skin in almost every part of the body is a continuous layer of areolar tissue, which is called the *superficial fascia*. In most cases it differs in no essential respect from the areolar tissue in other localities: it contains fat-cells, it furnishes a suitable medium for the lodgement of vessels and nerves on their way to and from various organs, and it both connects and separates structures between which it is interposed—always the skin on one surface, and usually the deep fascia on the other. It varies greatly in thickness, in some places being extremely thin and delicate, and in others very thick and large-meshed, the belly and buttock furnishing striking illustrations of the latter condition. Though it usually permits free movement of the skin on the subjacent parts, there are notable exceptions to the rule, as in the palm and sole, where it contains strong bands which lash down the skin tightly, and almost deprive it of mobility.

The superficial fascia is in some parts peculiarly modified: in the scrotum it contains no fat-cells, has mingled with its fibrous tissues a quantity of unstriped muscle, and is known as the *dartos*; in certain places it becomes condensed into a fibrous film, as in the *cribriform fascia*, which is stretched across the saphenous opening. Sometimes it is directly continuous with the other (deep) fascia, the latter thinning out and gradually losing itself in the areolar tissue. Occasionally the superficial adheres to the deep along a line of considerable length, as on the thigh near the inguinal ligament, and thus a subcutaneous accumulation of fluid is steered off in a special direction, as would not be the case but for this peculiarity. Two distinct layers are found in certain situations, as on the front of the abdomen, and they may differ considerably in structure, the more superficial generally containing more fat-cells, the deeper being more condensed. The veins which

course through this tissue are in some situations large and conspicuous, as on the dorsum of the hand and foot. Other organs are located in it, of which the most notable is the mammary gland.

The occasions for calling this structure other than subcutaneous areolar tissue are very infrequent; and, as the name "fascia," unless limited by an adjective, is usually employed in surgical parlance to designate the deep fascia, it will be thus used in the remainder of this chapter, unless specific exception is made.

THE DEEP FASCIÆ.

The typical deep fasciæ are close sheets of fibrous tissue, in which the white variety exists in an almost unadulterated form. On account of this histological composition these fasciæ are pearly white, flexible, strong, and inelastic. Their structure and physical qualities immediately bring to mind the characteristics of ligaments and tendons, which have identical structure; and the suggestion is especially apt for the reason that some fasciæ are really interosseous ligaments, and a number are properly to be regarded as tendons. Moreover, the employment of the word "fascia" is ofttimes arbitrary, as, for example, in the case of the transversalis abdominis muscle, whose tendon of origin is almost always described as a layer of the lumbar fascia, and whose tendon of insertion is conventionally dubbed an aponeurosis, although in both situations the tendons are sheet-like expansions, which serve for the ensheathing of muscles.

In this connection it is interesting and useful for the student to observe anew the continuity of the fibrous membranes—ligaments, tendons, and fasciæ blending with periosteum, tendons and fasciæ serving as ligaments, tendons losing themselves in fasciæ, tendons of some muscles acting as fasciæ for other muscles, and so on.

THE FASCIÆ OF THE HEAD.

A structure which may fairly be included in this group is the *epicranial aponeurosis*, which has already been described in connection with the muscles of the region (page 362).

The Temporal Fascia.

The *temporal fascia* has its superior attachment on the upper temporal ridge, its inferior on both borders of the zygoma, splitting into two layers just before reaching this arch. It encloses the temporal muscle, and is partially covered by the epicranial aponeurosis, the orbicularis palpebrarum, attrahens aurem, and attollens aurem.

The Masseteric Fascia.

The *masseteric fascia* is directly continuous with the cervical fascia. It covers the masseter muscle, and ends above at the lower border of the zygoma. In front it is in part attached to the coronoid process and in part blends with the buccinator fascia. Traced backward it is found to cover the parotid gland, and this portion is often called the *parotid fascia*.

The Buccinator Fascia.

The *buccinator fascia* covers the buccinator muscle. Above and below it is attached to the alveolar processes of the jaw-bones, behind is continuous with the masseteric fascia, and in front gradually thins out into areolar tissue.

THE CERVICAL FASCIA.

The deep fascia of the neck is conveniently divided for description into three portions: the outer or superficial, the middle, and the inner or deep, all of which, however, are continuous (Fig. 428).

The Outer Cervical Fascia.

The *outer portion* forms a firm investment for the organs of the neck, its shape being suggestive of a hollow cylinder. Its upper limit extends from the

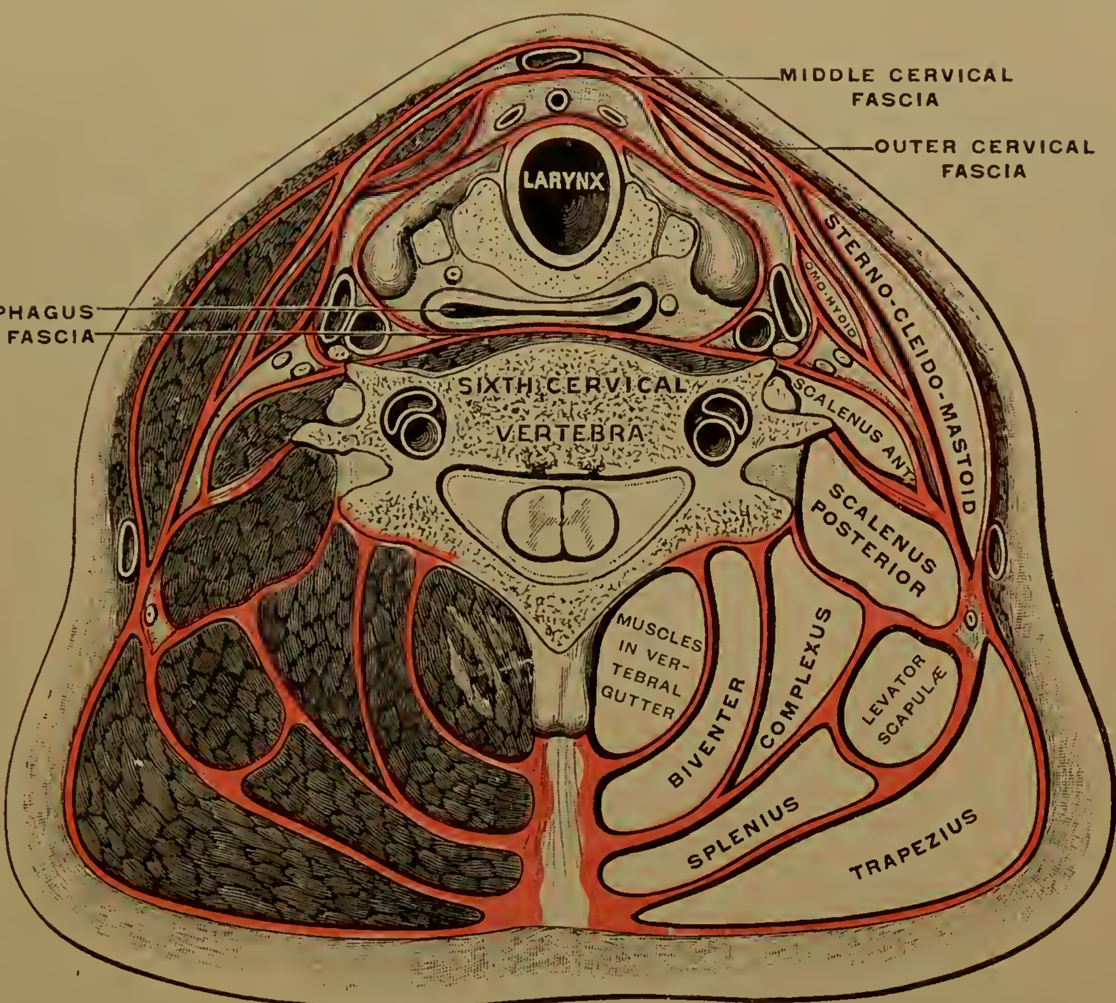

FIG. 428.—The cervical fascia, as seen in a horizontal section of the neck at the level of the sixth cervical vertebra. (Testut.)

external occipital protuberance to the lower part of the symphysis of the mandible, attaching itself to the series of skeletal prominences most nearly coinciding with a line drawn around the head and intersecting these points. Below it is fastened to the sternum, clavicle, acromion, and scapular spine, beyond the last named losing itself in the fascia of the back. Thus it includes, especially in its lower parts, somewhat more than the strict anatomical neck. It is attached behind to the ligamentum nuchæ, and in front it is continuous across the middle line. In its course around the side of the neck it splits twice, first embracing the trapezius, and then the sterno-mastoid, forming strong sheaths for these muscles. Traced from below upward in the region in front of the sterno-mastoid, it is found to be attached to the hyoid, from which it runs to its upper limit on the lower border of the mandible (Fig. 429). From the hyoid insertion it sends to the internal oblique line of the mandible a lamella, which lines the

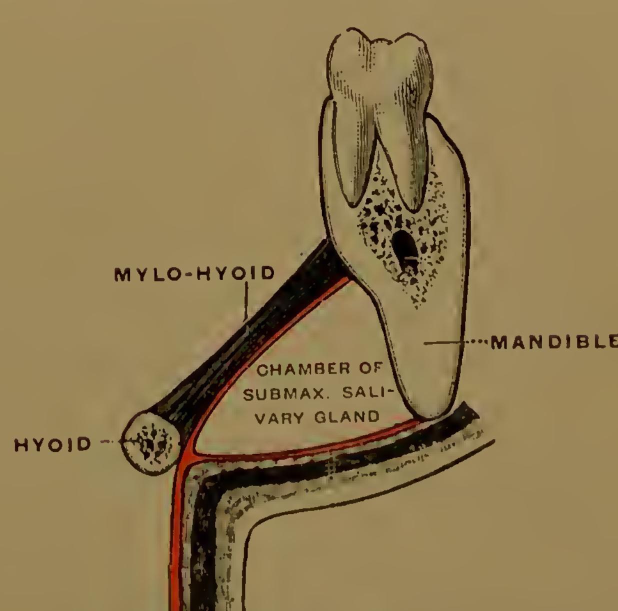

FIG. 429.—The outer cervical fascia between the hyoid and mandible. (Testut.)

under surface of the mylo-hyoid muscle. Thus it may be said that the fascia splits at the hyoid, and encloses between its two lamellæ a space, which is triangular in vertical section, and forms a chamber occupied by the submaxillary salivary gland. Below and in the middle line in front the fascia separates into two layers, one going to the anterior, the other to the posterior border of the top of the manubrium (Fig. 430). From the front of the portion of the fascia which forms a sheath for the sterno-mastoid, and where it is continuous with the masseteric fascia, a prolongation is given off forward and inward, is attached to the angle of the lower jaw, passes behind the parotid gland, and ends by insertion into the styloid process of the temporal, forming thus the *stylo-mandibular ligament* (Fig. 255).

The Middle Cervical Fascia.

The *middle portion* of the cervical fascia—that is, the portion between the superficial and deep layers—lies close behind the front part of the outer layer (Figs. 430, 431), arching between the omo-hyoids of the two sides, forming a sheath for each of them, and extends vertically from the hyoid to the sternum, and laterally from one scapula to the other, its side borders corresponding with the omo-hyoids. The part which ensheathes these muscles sends from each a band down to the sternum and the cartilage of the first rib. From the point where the fascia is attached to the middle line of the sternum a prolonga-

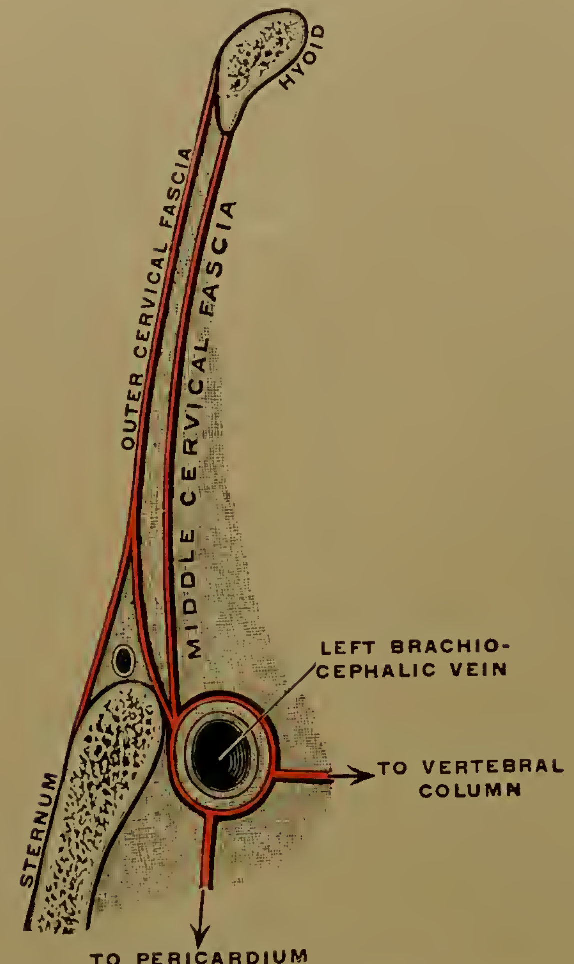

FIG. 430.—The cervical fascia between the hyoid and sternum. (Testut.)

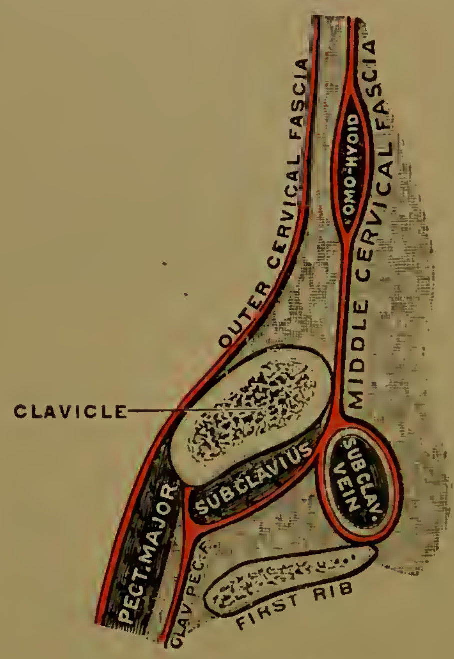

FIG. 431.—The cervical fascia in the clavicular region. (Testut.)

tion of it encircles the left brachio-cephalic vein (Fig. 430), and then passes down into the thorax and blends with the pericardium. On each side it is fastened to the clavicle, gives off expansions which encase the subclavian vein, and then are attached to the first rib and become continuous with the neighboring fasciæ (Fig. 431). A continuation of the middle layer enters into the formation of the sheath of the axillary vessels and nerves. Prolongations also are sent inward and furnish the neck muscles with sheaths; for the most part, however, these processes have not the firmness of the main layer, but are areolar in character.

The Inner Cervical Fascia.

The *inner* or *deep layer* of the cervical fascia, known also as the *prevertebral*, is continuous with the middle portion at the sheaths of the carotid arteries and internal jugular veins. It is attached above to the basilar process of the occipital bone, at the sides to the transverse processes of the cervical vertebræ, and below

gradually thins out and merges into the areolar tissue of the posterior mediastinum. In front of it are the pharynx and œsophagus, behind it the prevertebral muscles.

Peculiar interest attaches to these different portions of the cervical fascia on account of their influence upon the direction which accumulations of fluid will take when occurring in this region (Fig. 432). Fluid in front of the outer layer

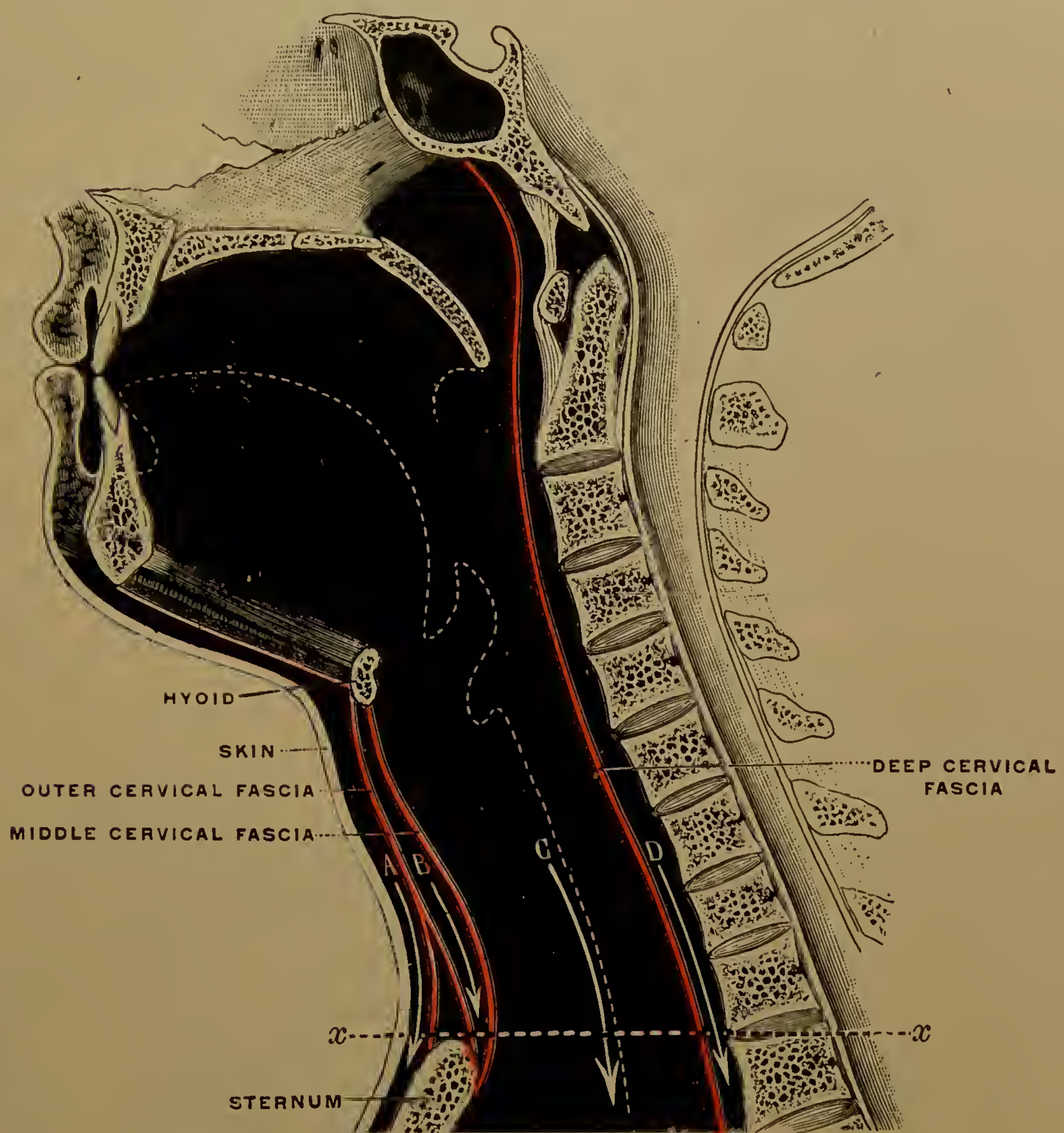

Fig. 432.—The cervical fascia as seen in sagittal section. (Testut.)

is confined to the subcutaneous region; between the outer and middle layers is kept from descending by the sternum; between the middle and inner or prevertebral is guided into the pharynx and œsophagus, or possibly into the larynx; and behind the last layer may be steered into the mediastinum.

THE THORACIC FASCIA.

This name, though often limited to the fascia of the pectoralis major, is much more fittingly applied to the entire series of fasciæ of the antero-lateral region of the chest, and is here employed in this sense.

The Pectoral Fascia.

The *pectoral fascia* (Fig. 433), thin and weak, covers the pectoralis major, and its attachments coincide with the margins of origin of this muscle. It turns around the lower border of the muscle and spreads upward over the hind surface. At the line where it makes the bend it is continuous with the true *axillary fascia*, a thick, strong membrane, which crosses the base of the armpit, describing an arch in its course, unites with the fascia which encases the latissimus, and through

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this last becomes attached to the spines of the thoracic vertebræ. At its outer side the axillary fascia merges with the sheath of the vessels and is continuous with the fascia of the arm; it is also connected with the fascia of the shoulder.

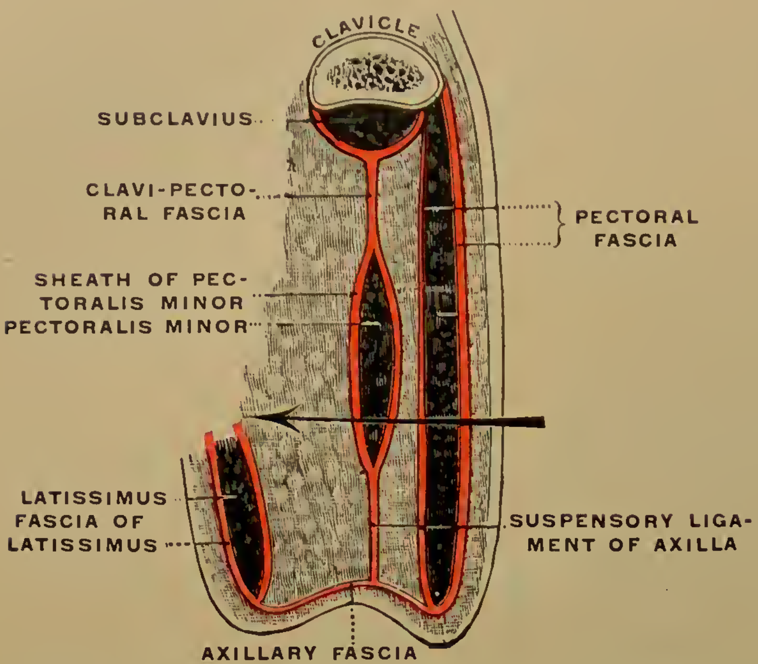


FIG. 433.—The pectoral and axillary fasciæ, seen in sagittal section. (Testut.)

The Clavi-coraco-axillary Fascia.

This is a quadrilateral sheet which runs vertically from the clavicle and coracoid process above to the fascia of the armpit below, and lies just behind the pectoralis major (Fig. 434). It has a double attachment to the clavicle, one layer being in front, the other behind, and between them is lodged the subclavius, to which they furnish a strong sheath. The hind layer is continuous with the sheath of the axillary vessels, which extends downward from the cervical fascia. In the middle of its course the clavi-coraco-axillary fascia splits and closely embraces the pectoralis minor between its layers. From the lower (outer) border of this muscle it is again single, and, extending outward, unites with the sheath of the coraco-brachialis. The portion of the fascia above the pectoralis minor, being fastened internally to the first rib, is named the *costo-coracoid membrane* and *clavi-pectoral fascia.* The uppermost part of it is the strongest, and is called the *costo-coracoid ligament.* The portion of the fascia between the pectoralis minor and the coraco-brachialis is triangular, its apex being at the coracoid process, its base at the lowest part of the axilla. It serves to preserve the hollow of the armpit, and has, consequently, been named the *suspensory ligament of the axilla.*

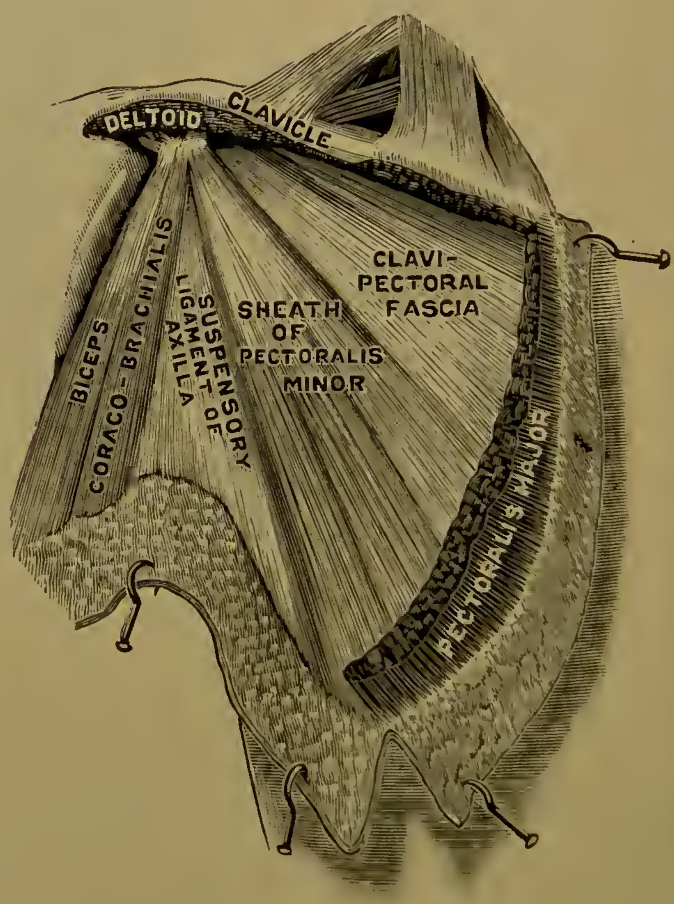


FIG. 434.—The clavi-coraco-axillary fascia of right side, front view. (Testut.)

The Intercostal Fasciæ.

The external intercostal muscles are covered on their outer surfaces and the internal intercostal on their inner surfaces by the fibrous membranes, which are called respectively the *external* and *internal intercostal fasciæ.* They are most pronounced in the portions of the spaces between the ribs which are not occupied by both varieties of these muscles. A thinner fascia separates the muscles of each space.

THE FASCIÆ OF THE SHOULDER.

In the region of the shoulder are the subscapular, supraspinous, infraspinous, and deltoid fasciæ (Fig. 435).

The Subscapular Fascia.

The *subscapular fascia* is attached to the margins of the fossa of the same

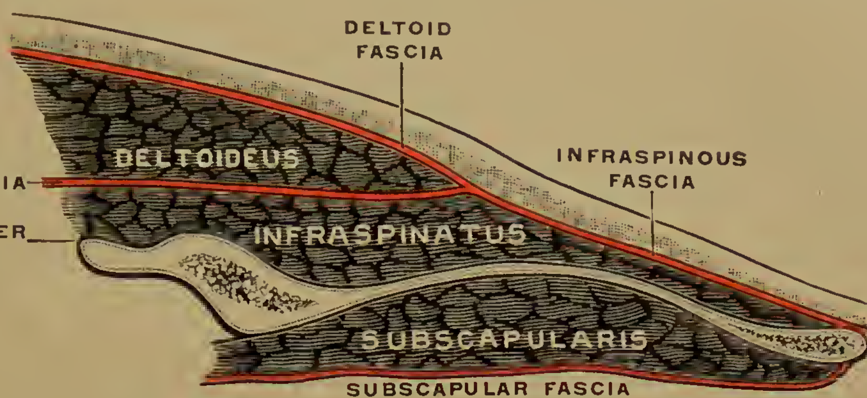


FIG. 435.—The fasciæ of the shoulder, seen in horizontal section. (Testut.)

name, and forms a covering for the subscapularis muscle.

The Supraspinous Fascia.

The *supraspinous fascia*, dense and strong, is attached to the borders of the fossa above the spine of the scapula, thus completing the osseo-fibrous chamber, which is filled by the supraspinatus muscle.

The Infraspinous Fascia.

The *infraspinous fascia* is like the last named in structure and similar in arrangement, being attached at the edges of the lower fossa on the dorsum of the scapula, thus forming with the bone a cavity, which is completely occupied by the infraspinatus. Where this muscle is overlapped by the hind border of the deltoid the fascia splits, one layer passing upon the latter muscle and forming part of the deltoid fascia, the other going in front of the deltoid and ending by fusion with the fibrous structure of the shoulder-joint.

The Deltoid Fascia.

The *deltoid fascia* covers in the deltoid muscle. It is continuous behind with the infraspinous fascia, in front with the pectoral. It is fastened above to the bones from which the muscle takes origin, and is continuous below with the fascia of the arm.

THE FASCIA OF THE ARM.

The *brachial fascia* is continuous above with the pectoral and axillary fasciæ, as well as with that of the shoulder, and below with that of the forearm. It is attached to the condyles of the humerus and the olecranon process. It not only enwraps the muscles of the brachial region, but from its inner surface sends septa between them. The greater part of these partitions are merely areolar, but two are strong and rigid, and need especial mention. One of them is attached to the outer lip of the bicipital groove, the outer supracondylar ridge, and the intervening portion of the shaft; the other is similarly situated on the inner side—thus being formed the *external* and the *internal intermuscular septa*, which divide the muscles into an anterior and a posterior set.

THE FASCIA OF THE FOREARM.

The *forearm fascia* is a direct continuation of the brachial fascia above, and ends below in the fascia of the hand. It has attachments to the olecranon and the posterior border of the ulna. From its inner surface many septa are given

off and extend between the muscles. For the most part these are areolar; but near the elbow, where groups of muscles arise from the condyles, the fibrous partitions are well marked. Between the first and second layers of the flexor muscles is stretched a thin layer of fascia, and a similar one is found between the superficial and deep groups of extensors. The fascia is much thicker behind than in front. At the lower end of the forearm the fascia terminates in the so-called annular ligaments, anterior and posterior. The name implies a ring-like structure; but each extends only half-way round the limb, and, while the posterior is almost entirely within the limits of the forearm, the anterior is wholly within the boundaries of the hand.

The Posterior Annular Ligament.

The *posterior annular ligament* (Fig. 437) is chiefly composed of transverse bundles of fibres constituting a broad and strong band, which has bony attachments on the inner side to the styloid process of the ulna, the cuneiform and the pisiform, on the outer side to the lower end of the ventral border of the radius, and between these extremities to the vertical ridges on the back of the radius. In this way are formed six osseo-fibrous passages, lined with synovial membrane, and occupied by the tendons of the extensor muscles of the forearm which are inserted in the hand.

THE FASCIÆ OF THE HAND.

In the hand are the anterior annular ligament, the palmar fascia, the interosseous fasciæ, the superficial transverse ligament, the dorsal fascia, and the sheaths of the tendons of the digital muscles.

The Anterior Annular Ligament.

The *anterior annular ligament* runs transversely across the front of the carpus from the scaphoid and trapezium on the outer side to the pisiform and unciform on the inner, thus converting the groove of the carpus into a tubular passage, through which run the flexors of the digits. It is continuous above with the forearm fascia, and below with the palmar fascia.

The Palmar Fascia.

The *palmar fascia* is divided into three parts, a middle and two lateral. Of these the middle is the most important, and often no other part is intended when the term "palmar fascia" is employed.

The *middle palmar fascia* is thick and strong, and seems to be in great part an expansion of the palmaris longus, though there appears to be no lack of the fascia in cases where the muscle is absent. Other portions originate from the anterior annular ligament. The fascia spreads out in fan-shape as it descends, is firmly adherent to the skin, and is inserted into the bases of the four fingers by a division for each. From these divisions slips are sent to the skin, the anterior metacarpo-phalangeal ligament, the sides of the neighboring metacarpal bones, and the digital sheaths, which will presently be described. From the lateral borders of the fascia a partition passes backward to the interosseous fascia, and in this way is formed a canal in which are lodged the tendons which traverse the palm.

The *lateral portions of the palmar fascia* are thin, cover the thenar and hypothenar groups of muscles, and, extending around the borders of the hand, become continuous with the dorsal fascia.

The *anterior interosseous fascia* is a thin layer which lies in front of the interosseous muscles, and is attached to the anterior ridges of the metacarpal bones.

In the interdigital commissures is a thin band, which extends from the index to the little finger, and forms the basis of the webs. It is called the *superficial transverse ligament.*

The Dorsal Fascia of the Hand.

This is a thin layer, continuous on each side with the lateral parts of the palmar fascia, above with the fascia of the forearm, and below with the sheaths of the extensor tendons. Between the metacarpal bones are stretched delicate fasciæ, which cover the dorsal interosseous muscles.

Fascial Sheaths of Tendons in the Hand.

On the palmar aspect of the digits each flexor tendon runs in a tubular canal, made by the concaved phalangeal surfaces and strong fibrous bands, which arch over these from the lateral margins of the bones. The bands are called *vaginal ligaments,* because they help to form the sheath (*vagina*) of the tendon. They are very dense opposite the shaft of the phalanx, much thinner opposite the joints. Each of the canals is provided with a vaginal synovial membrane (Fig. 436). Those of the index, middle, and ring fingers are independent, cylindrical sheaths, covering the length of two phalanges; that of the thumb, also, is separate, and extends from about two inches above the radiocarpal joints to the interphalangeal articulation; and that of the little finger, starting a trifle higher in the forearm, reaches to the distal end of the second phalanx, and includes also the flexor tendons of the other fingers as far as half-way down the palm.

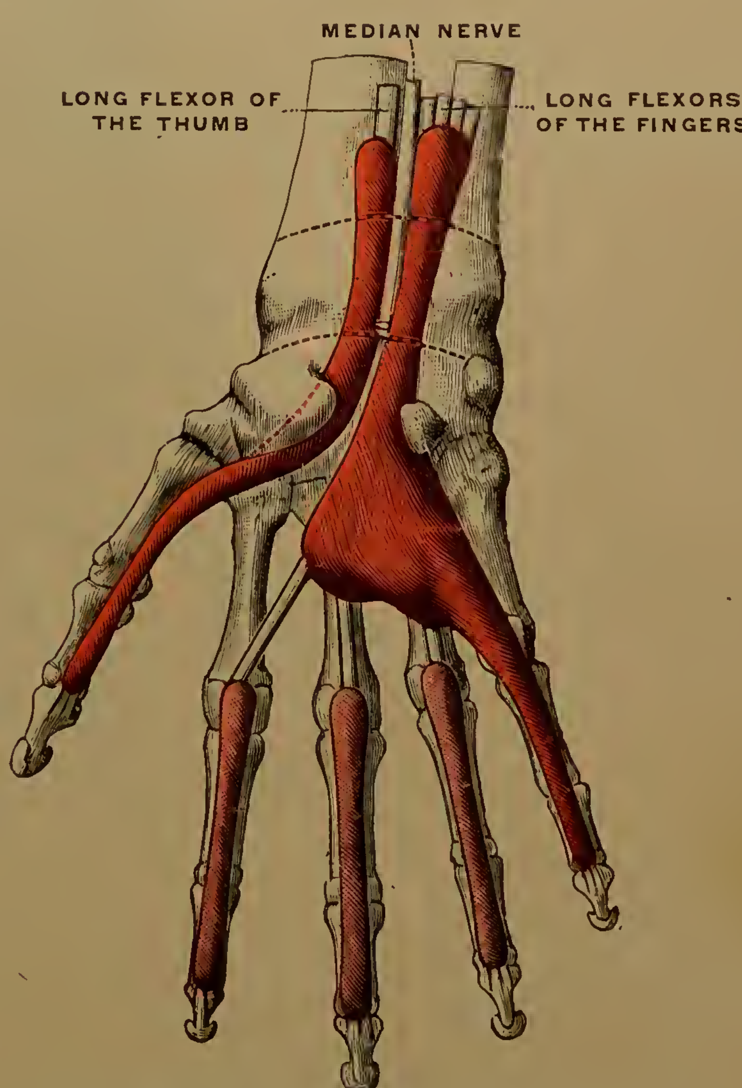


FIG. 436.—Synovial membranes of tendons in the palm, artificially distended. (Testut.)

On the dorsal aspect of the hand a different arrangement obtains (Fig. 437). The tendons of the digital extensors spread out upon the back of the first and second phalanges and blend at the sides with the lateral ligaments of the joints from the metacarpo-phalangeal down, themselves acting as posterior ligaments. As has already been said, the posterior annular ligament forms with the hind surface of the adjacent bones of the forearm a series of tubular canals, through which extensor tendons pass. These channels are provided with vaginal synovial membranes, which extend above and below the limits of the ligament. They contain tendons as follows: the first—that on the radial border—the extensor ossis metacarpi pollicis and the extensor brevis pollicis; the second, the extensores carpi radiales longus and brevis; the third, the extensor longus pollicis; the fourth, the extensor communis digitorum and the extensor indicis; the fifth, the extensor minimi digiti; and the sixth—that on the ulnar border—the extensor carpi ulnaris.

THE FASCIÆ OF THE BACK.

The Vertebral Fascia.

The *vertebral fascia* is an extension downward of the back part of the outer layer of the cervical fascia. It stretches from the spinous processes of the thoracic vertebræ to the angles of the ribs, covering in the deep vertical muscles of the

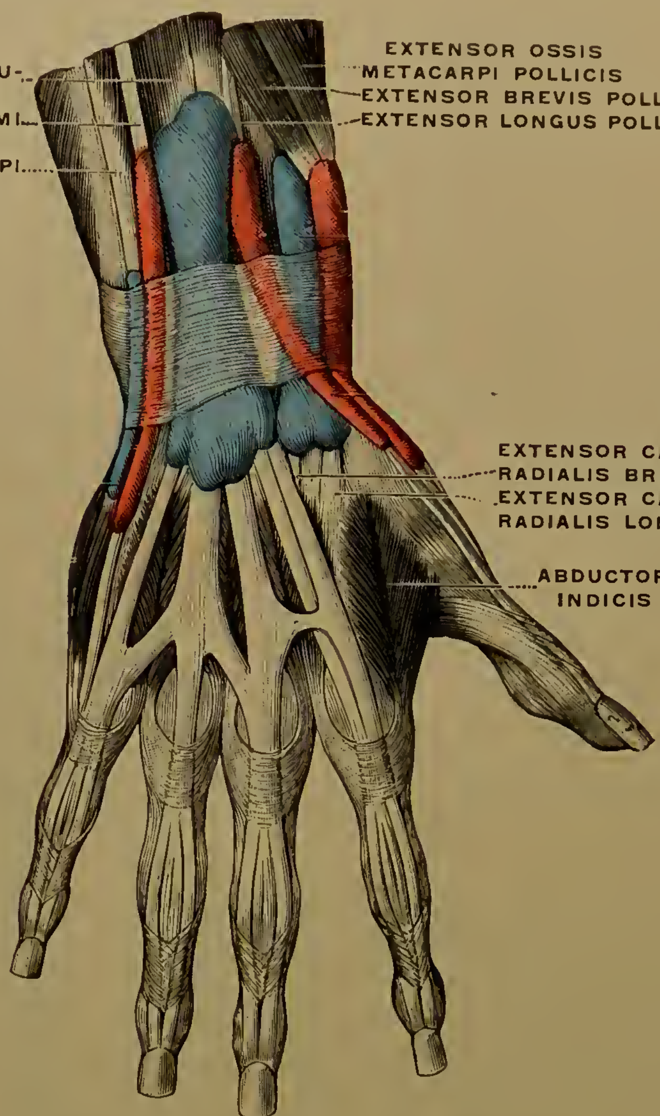


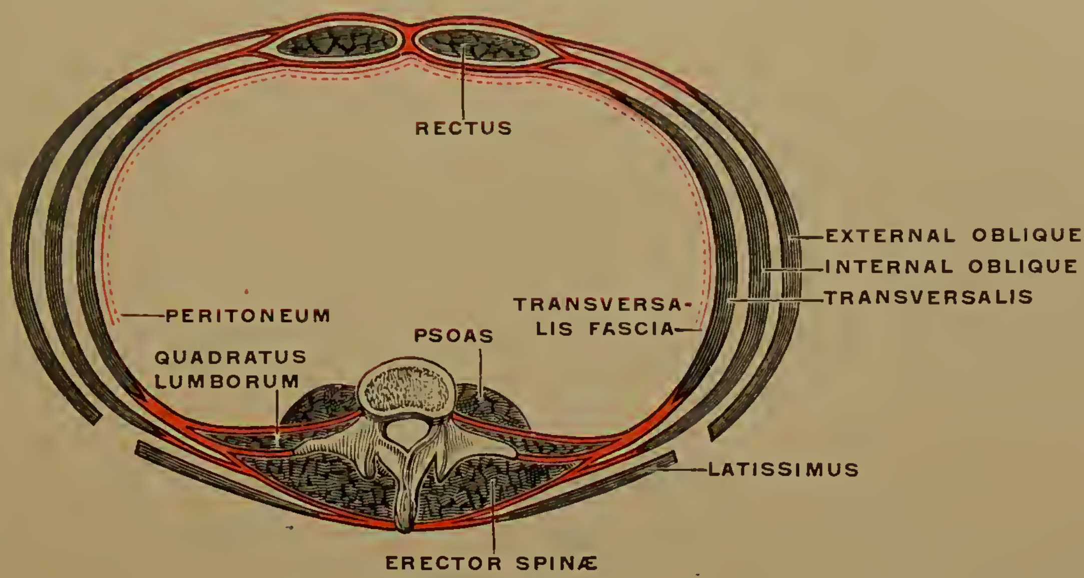
FIG. 437.—Synovial membranes of tendons in the dorsum of the forearm and hand, artificially distended. (Testut.)

back, passing in front of the serratus posterior superior, and becoming continuous below with the lumbar fascia.

The Lumbar Fascia.

The *lumbar fascia* (Fig. 438) is, in reality, rather a combination of tendons than a true fascia of investment, although it serves also in the latter capacity. The latissimus, serratus posterior inferior, obliquus internus abdominis, and transversalis abdominis all participate in its formation. Regarded as a fascia, it springs from the vertebral column in three layers, the outer or posterior, the middle, and the inner or anterior. The *outer layer* begins at the tips of the spinous processes of the lumbar and sacral vertebræ, forming a direct downward continuation of the vertebral fascia. It is attached above to the last rib, and below to the hind third of the outer lip of the iliac crest and the ilio-lumbar ligament. The *middle layer* starts from the free ends of the transverse processes of the lumbar vertebræ; and the *inner layer* arises from the front of the bases of the same processes. The outer and middle unite at the outer edge of the erector spinæ, which occupies the space between them; and this double layer is joined by the inner a little farther away from the middle line, the enclosure thus bounded being filled by the quadratus lumborum. The fascia resulting from the combination of the three layers gives

origin to the transversalis abdominis; the obliquus internus abdominis is inserted into a secondary lamella, which splits off from the outer layer; and the latissimus and serratus posterior inferior arise from still another lamina, which separates from the main fascia nearer the median line.



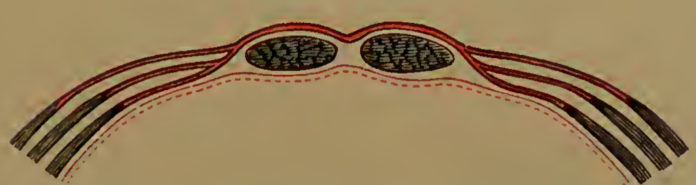


FIG. 438.—Semidiagrammatic horizontal section of trunk to show the lumbar fascia and the tendons of the lateral abdominal muscles. The upper figure shows the complete sheathing of the rectus in its superior portions; the lower shows the arrangement in its inferior fourth. (Testut.)

The front portions of the abdominal wall are largely made up of the tendons of insertion of the external oblique, internal oblique, and transversalis muscles, and these tendons are fasciæ in the same sense that the different tendons are, which constitute the lumbar fascia; but they are rarely mentioned other than as aponeuroses of insertion—a term which implies their tendinous character.

THE FASCIÆ OF THE ABDOMINAL CAVITY.

The abdominal cavity is everywhere lined with a serous membrane, the peritoneum. Between this, which furnishes the free surface of the cavity, and the muscular portion of the abdominal walls is interposed a delicate membrane, which, in the greater part of the abdomen proper, is known as the *transversalis fascia*, on account of its intimate connection with the great muscle against whose inner surface it lies, and, in the back part of the abdomen proper and in the pelvis, is called the *iliac fascia*, because the iliacus is one of the great muscles with which it is in close relation, the other being the psoas. Each of these fasciæ is somewhat prolonged beyond the abdominal cavity, as will presently be detailed.

The Transversalis Fascia.

The *transversalis fascia* is thickest at the groin, gradually becomes thinner as it is traced upward, and is nothing but areolar tissue where it lines the under side of the diaphragm. It is attached to the inner border of the iliac crest, the outer half of the inguinal ligament, the spine of the pubic bone, and the ilio-pectineal line. Beneath the inguinal ligament, a little to the inner side of its middle, the great vessels of the thigh, the femoral artery and vein, are found, the vein nearer the median line of the body. In front of these vessels this fascia is prolonged, forming the anterior part of their common sheath (the *femoral* or *crural sheath*), the posterior part being contributed by the iliac fascia. As the transversalis fascia escapes from the abdomen at this point, it is strengthened by a band, which

curves over the vessels, and is called the *deep crural arch*. The inner portion of this arch is the part of the fascia which is attached to the os pubis and ilio-pectineal line. Between the femoral vein and Gimbernat's ligament is a little gap, the *femoral ring*, through which hernia is most liable to occur in females, this being the weakest spot in the inguinal region of the members of this sex. It is the abdominal opening of the femoral or crural canal, and is occupied by a lymph-node and some fat. About half-an-inch above the middle of the inguinal (Poupart's) ligament is an oval opening in the transversalis fascia, called the *internal abdominal ring*. It is the beginning of the inguinal canal, the other end of which is in the tendon of the external oblique muscle, just above the crest of the pubic bone. Through this canal passes the spermatic cord in the male and the round ligament of the uterus in the female. In each case the transversalis fascia is extended upon the structure contained in the canal, forming a covering which from its funnel-shape is called the *infundibuliform fascia*.

The Iliac Fascia.

The *iliac fascia* lies upon the iliacus and psoas muscles, which, as has been said, are intimately connected. The portion which covers the psoas is attached to the vertebral column coextensively with the front origin of the muscle, and also to the upper part of the sacrum. From this mesial origin it runs outward, its upper part joining the inner (anterior) layer of the lumbar fascia, its lower part blending with the fascia over the iliacus. Its upper end is attached to the ligamentum arcuatum internum. The portion of the fascia which invests the iliacus stretches from the inner margin of the iliac crest to the iliac part of the ilio-pectineal line, and is also attached to the outer half of the inguinal (Poupart's) ligament. It accompanies the united muscles out of the pelvis into the thigh, and, running behind the femoral artery and vein, furnishes the posterior part of the sheath of these vessels, the front part of which is derived from the transversalis fascia. It finally becomes continuous with the pubic portion of the fascia of the thigh, at the line of fusion of the two a partition being given off between the psoas and pectineus to the ilio-pectineal eminence and the capsular ligament of the hip.

THE PELVIC FASCIA.

In direct downward continuation of the transversalis and iliac fasciæ, which belong to the abdomen proper, is the *pelvic fascia*, which, as the name implies, lines that portion of the belly-cavity which is known as the true pelvis (Fig. 439).

Besides the osseous and ligamentous structures presenting surfaces in the pelvic cavity, there are the internal obturator muscles at the sides, the pyriformis muscles behind, and the levatores ani and coccygei below. The levators arise along a line from the body of the pubic bone to the ischial spine, pass downward toward the median line, and there blend, thus forming the greatest part of the sagging floor of the pelvic cavity. This floor is perforated by the rectum, and in the female by the vagina also, and it separates the pelvic cavity from the subjacent perineal or ischio-rectal space. All of these parietal structures are lined by the pelvic fascia, which also gives support to the viscera.

Two principal portions of the pelvic fascia are recognized—the obturator fascia and the recto-vesical fascia.

The Obturator Fascia.

The *obturator fascia*, so named from its lying upon the surface of the obturator internus muscle, is attached to the bone around the margin of the muscle, being continuous with the obturator membrane beneath the obturator vessels, and, extending back to the front of the sacrum, covers the pyriformis and the sacral nerves, in this region being much attenuated. This hind portion is sometimes

called the *pyriformis fascia.* As the obturator internus leaves the pelvis it takes with it a reflection of its fascia, which thus becomes continuous with the fascia which invests the muscles in the hip and thigh.

FIG. 439.—Diagram of a coronal section of the pelvis, designed to show the relations of the pelvic fascia and the ischio-rectal fossa. V. S.=Vesicula seminalis.

The Recto-vesical Fascia.

Along the curved line which marks the upper border of the origin of the levator ani (*i. e.*, from the symphysis pubis to the ischial spine) the fascia is somewhat thickened, and is called the *white line* (arcus tendineus, linea albuginea). From this line the *recto-vesical fascia* arises, and extends toward the median line in close contact with the upper surface of the levator ani. When it reaches the bladder, it splits into two layers, one of which spreads upward and disappears in the wall of this viscus, and the other passes downward upon the prostate gland, and thus forms its sheath. The portion around the prostate is continuous with the upper layer of the triangular ligament, which will presently be described.

When the recto-vesical fascia reaches the rectum, its fibres intermingle with those of this intestine. In the female the fascia forms a partial covering to the vagina.

Certain portions of the recto-vesical fascia are described as the *true ligaments of the bladder*; but the lateral and the posterior are generally so indistinct as to be demonstrable with difficulty, if at all, and only the anterior are constantly worthy of mention.

A little to each side of the median line a fold of the fascia runs forward from the bladder, and attaches itself to the body of the pubic bone. This fold encloses a small bundle of muscular tissue, which is called, from the parts which it connects, the *vesico-pubic muscle.* Thus are formed the *anterior ligaments of the bladder.* Between these two ridges is a median depression, in which the fascia is thin.

THE FASCIÆ OF THE PERINEUM.

The *deep fascia of the perineum* forms a triangle with its apex forward, and is often called the *triangular ligament of the perineum*. It extends nearly horizontally sidewise between the lateral walls of the pelvis, and ventro-dorsally from the pubic symphysis to the central point of the perineum, which is about an inch in front of the anus. At the base of the triangle the fascia is single, but immediately splits into two layers, the superficial and the deep, between which are situated the constrictor muscle of the urethra, the suburethral (Cowper's) glands, vessels and nerves, as well as a part of the urethra. From this last fact and its

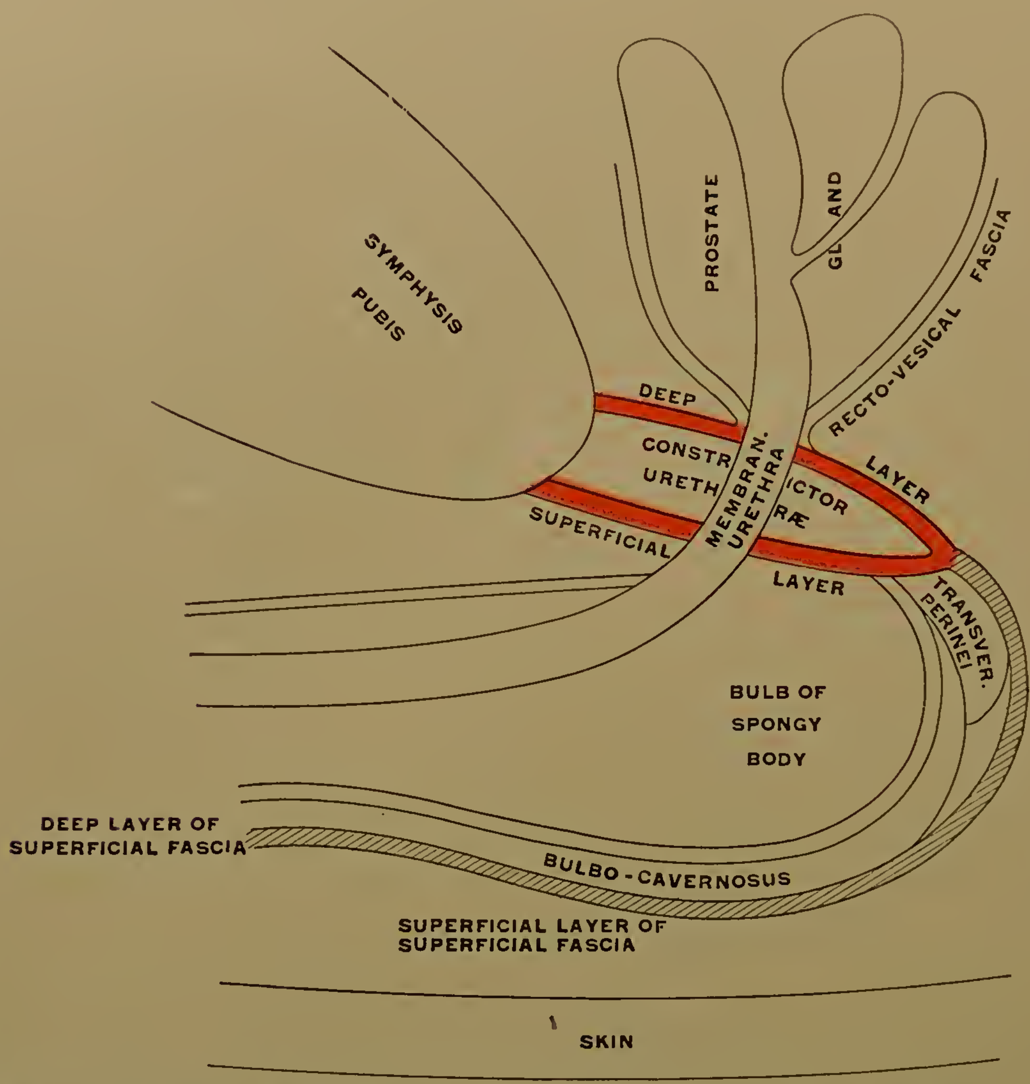


FIG. 440.—Diagram of a median sagittal section of the anterior portion of the perineum, designed to show the relations of the triangular ligament (red).

shape the fascia is most commonly known as the *triangular ligament of the urethra* (Fig. 440).

The *superficial* (inferior) *layer* stretches between the ischio-pubic rami, strengthened near the front by a fibrous band, called the *transverse ligament of the pelvis*.

The *deep* (superior) *layer* is connected laterally with the obturator fascia, just above the latter's attachment to the pubic and ischial rami.

In the female the vagina perforates this fascia.

The *superficial fascia* requires a more detailed description in the perineum than in most other localities. Its *deep layer* (fascia of Colles) is rather firm and close, and is attached at the sides to the entire lower border of the ischio-pubic rami and the ischial tuberosities. Its hind margin is united to that of the triangular ligament, between which structure and it are the transversus perinei muscles. Between this deep layer and the skin is the *superficial layer*, loose and areolar, its spaces occupied with fat-cells.

The name *ischio-rectal fossa* is applied to the considerable space on each side between the sagging floor of the pelvis and the osseo-muscular pelvic wall. The outer wall of this fossa is lined by the lower part of the obturator fascia, the

inner wall by a thin, fibrous lamina, which covers the lower (external) surface of the levator ani, and is called the *ischio-rectal* or *anal fascia.* The fossa is prolonged forward over the superior layer of the triangular ligament. These fossæ are commonly filled with adipose tissue, which is continuous with that subjacent to the skin of the buttocks.

THE FASCIÆ OF THE HIP AND THIGH.

These structures are not separated by a clearly defined boundary, and will be considered as one, which, on account of its great extent, is commonly called *fascia lata* ("the broad band"). It is cylindrical in shape, and extends from the highest margin of the hip to the lowest limit of the thigh. At its upper end it is attached along an irregular line, which lies successively upon the coccyx, sacrum, iliac crest, the inguinal (Poupart's) ligament, the body and descending ramus of the os pubis, the ascending ramus and tuberosity of the ischium, and the great sacro-sciatic ligament, thus completing the circuit. It also has an attachment to the ilio-pectineal line, which will be mentioned again presently. It is continuous below with the fascia of the leg, is attached by its deep surface to the bony prominences around the knee, and contributes to the formation of the capsular ligament of this joint. In most parts it is a single layer, but, in the region of the gluteus maximus, it has two lamellæ, which ensheathe the muscle, and a similar arrangement obtains in the case of the tensor vaginæ femoris, otherwise called the tensor fasciæ latæ. The portion of the fascia on the outer aspect of the thigh is the strongest, and is called the *ilio-tibial band,* from its attachments at the iliac crest and the outer tuberosity of the tibia. The fascia sends inward to the femur two *intermuscular septa,* which partition the thigh into an anterior compartment and a posterior, the former containing the quadriceps and sartorius, the latter the other muscles. These septa, external and internal, have their osseous attachments respectively upon the outer and inner lips of the linea aspera and their upward and downward prolongations. Other and less important septa also occur. Just below the median end of the inguinal (Poupart's) ligament is an oval hole, measuring about an inch in its long (vertical) diameter, and called the *saphenous opening,* from its transmission of the long saphenous vein. The saphenous opening is closed in by a thin layer of areolar tissue (superficial fascia), which, from its being perforated by many vessels, suggests a sieve, and hence is called the *cribriform fascia.* The part of the fascia at the outer side of this aperture is the *iliac portion*; the part at the inner side is the *pubic portion.* The saphenous opening may be regarded as a notch in the upper border of the fascia, the angles of the notch overlapping each other without contact, so that the opening has not a continuous margin. The part of the margin which comes in front is continuous with the inner end of the inguinal (Poupart's) ligament; that which goes to the rear curves backward, and is attached to the ilio-pectineal line. The upper, outer, and under portions of the rim taken together are sickle-shaped, and bear the name of *falciform process.* It is attached to the front of the sheath of the femoral vessels. Behind the plane of the saphenous opening are the upper parts of the femoral artery and vein. Elsewhere these vessels, like others generally, are enclosed in a snugly fitting sheath; but here for about three-quarters of an inch they are clothed with a somewhat loosely fitting investment, the *femoral* or *crural sheath,* the anterior portion of which is a prolongation

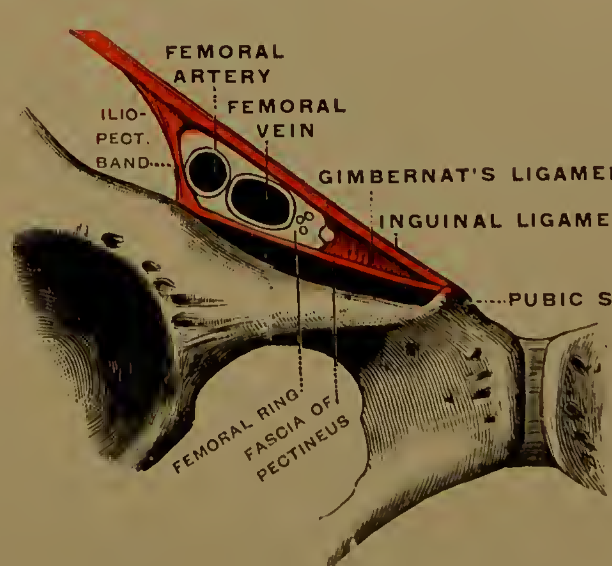


FIG. 441.—The femoral ring. (Testut.)

of the transversalis fascia, the posterior part an extension of the iliac fascia. The femoral sheath has the shape of a funnel with its large end up, and its small end down, continuous with the sheath of the distal portion of the vessels. Two vertical septa divide the space included by the femoral sheath into three compartments, in the outer of which lies the femoral artery, in the middle the femoral vein, and in the inner a little adipose tissue, and perhaps a small lymph-node, which fill the space but imperfectly. The inner compartment is the *femoral* or *crural canal.* Its upper end about half an inch across, between the femoral vein and Gimbernat's ligament, is the *femoral* or *crural ring,* and is closed by a rather firm layer of areolar tissue, the *septum crurale.* The anterior part of the femoral sheath at its highest level is enforced by a transverse band, which curves over the vessels and is known as the *deep crural arch.* At its outer end the arch is connected with the iliopectineal line and the fascia covering the pectineus by a fibrous cord, the *iliopectineal band.* The obturator artery usually courses close to the outer side of the femoral ring; but it may run on the mesial side of the ring—a fact to be remembered in operating on a femoral hernia, which protrudes through the weak spot in the abdominal wall afforded by the femoral ring and canal.

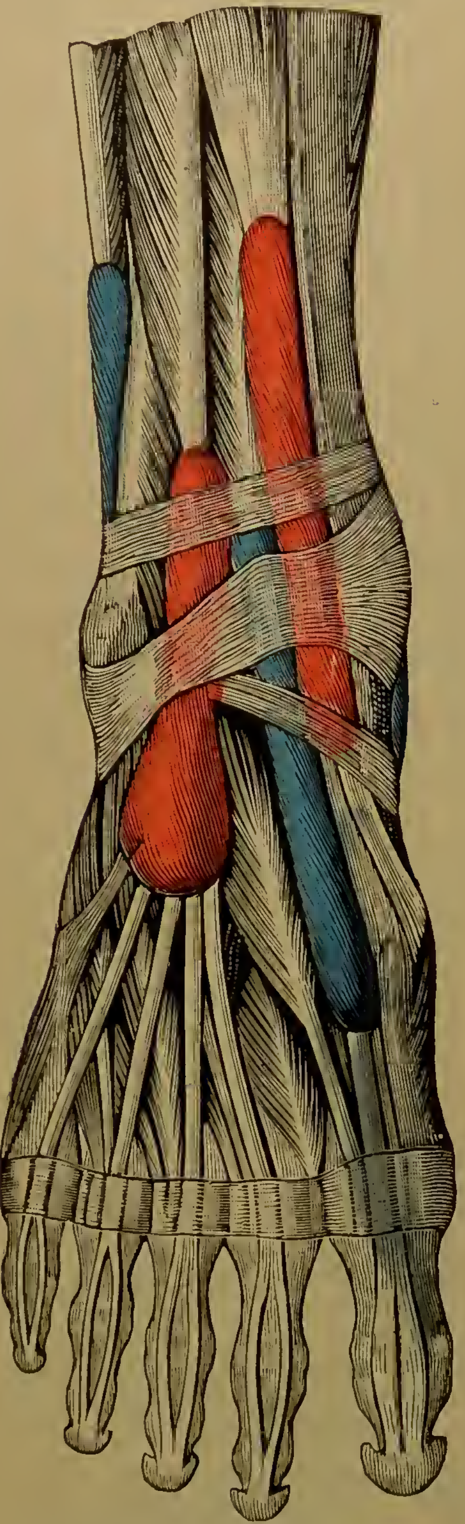


FIG. 442.—The anterior annular ligament of the ankle and the synovial membranes of the tendons beneath it artificially distended. (Testut.)

THE FASCIÆ OF THE LEG.

The principal fascia of the leg is directly continuous with that of the thigh above and that of the foot below. It is not, however, a complete enclosure for the leg, being deficient at the places where the bony framework is subcutaneous. For example, at the inner surface of the tibia the fascia merges with the periosteum at the borders of this area; and it is disposed in like manner at the heads of the tibia and fibula, and at the malleoli. It sends *intermuscular partitions* inward at several points, the most perfect of them being two on the outer side of the leg which have bony attachments along the neighboring borders of the fibula, and separate the peronei longus and brevis from the front and back groups of muscles respectively. Between the muscles which are inserted into the calcaneum and the other posterior muscles is stretched the *deep transverse fascia,* attached to the tibia and fibula, and binding down the muscles in front of it.

In the region of the ankle the fascia is strengthened and to some extent prolonged into the foot by a series of transverse bands, which nearly encircles the limb, each of its primary divisions being called an annular ligament. They are three in number—anterior, internal, and external. The *anterior annular ligament* (Fig. 442) consists of two parts, an upper and a lower. The *upper band* runs across the front of the leg between the anterior borders of the tibia and fibula, just above the malleoli, keeping the vertical tendons in place. The *lower band* begins on the outer side of the calcaneum, and splits into two layers at the outer border of the peroneus tertius, one going in front and the other behind; at the inner border of the extensor longus digitorum the layers unite, thus forming a channel through which these two

muscles pass. The band then divides into two branches—a superior, which goes upward to the front of the inner malleolus, and is there attached; and a lower, which crosses to its insertion on the scaphoid and internal cuneiform bones and in the plantar fascia. These bands confine the tendons of the tibialis anterior and extensor proprius hallucis closely to the subjacent structures. Each of the last-named has a synovial sheath, but the extensor longus digitorum and peroneus tertius have one in common. The *internal annular ligament* (Fig. 443) is stretched between the internal malleolus and the postero-inferior part of the inner surface of the os calcis. From its deep surface processes are given off to the neighboring ridges of bone, thus forming compartments through which pass the tendons of muscles from the back of the leg to the sole of the foot, as follows: next behind the malleolus the tibialis posterior, then the flexor longus digitorum, and, finally, after an interval in which lie the vessels and nerves, the flexor longus hallucis. Each of the tendons has its separate synovial membrane. The *external annular ligament* (Fig. 444) runs from the tip of the external malleolus to the outer side of the calcaneum, binding down the peroneus longus and peroneus brevis, which are enclosed together in a single synovial membrane.

THE FASCIÆ OF THE FOOT.

The homology of the fasciæ of the foot and hand is so marked that it is unnecessary to dwell minutely upon the former, the latter having been already described. That in the sole is called the *plantar fascia,* and is divided into three parts. The central portion starts from the inner tuberosity of the calcaneum, runs forward below the flexor brevis digitorum, and terminates in front in a process for each toe and in slips for the skin. At the sides it is continuous with

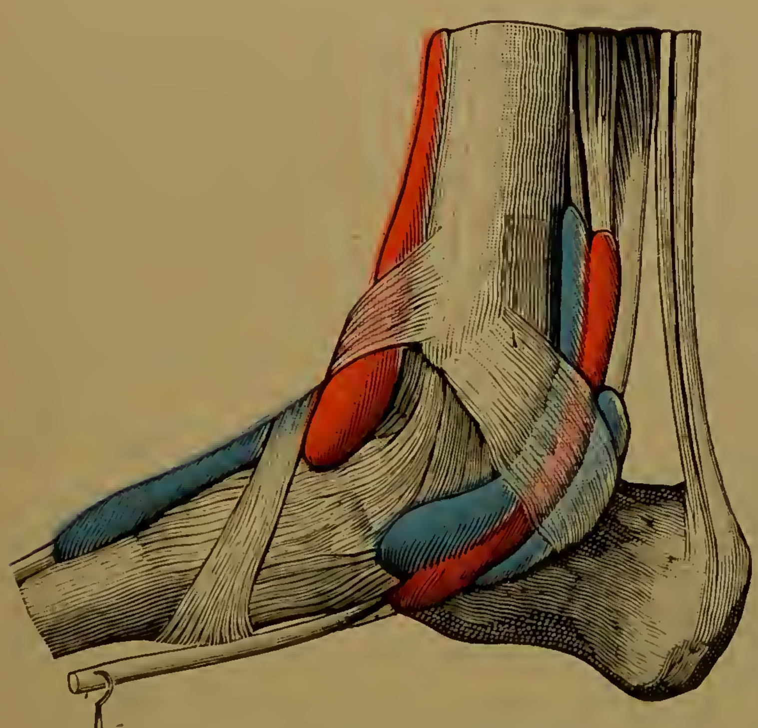


Fig. 443.—The internal annular ligament of the ankle and the artificially distended synovial membranes of the tendons which it confines. (Testut.)

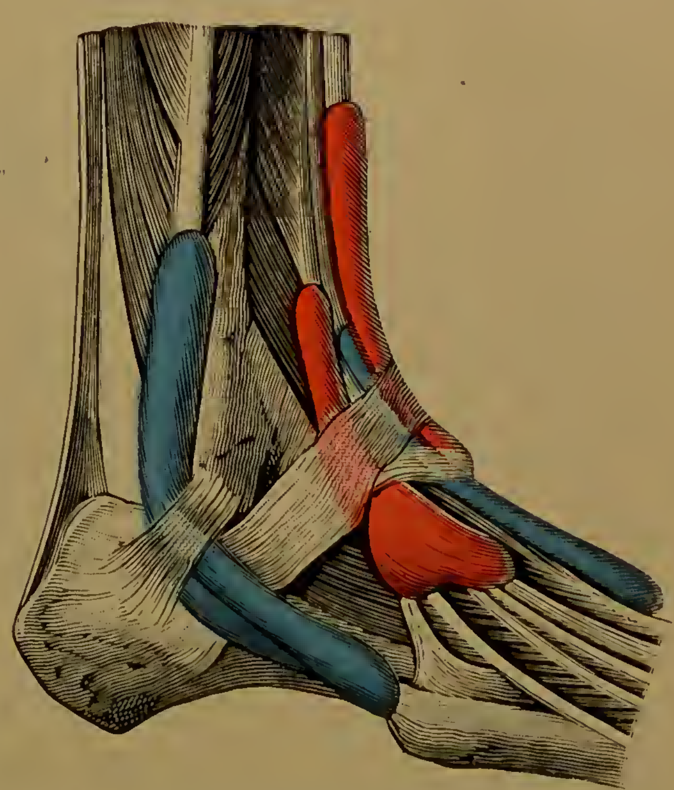


Fig. 444.—The external annular ligament of the ankle and the artificially distended synovial membrane of the tendons which it confines. (Testut.)

the lateral portions, which extend around the margins of the foot. Where the central portion joins each lateral a process passes upward, and thus are formed partitions between corresponding groups of muscles. The external lateral portion is attached behind to the calcaneum, the internal to the internal annular ligament. The interosseous fasciæ, the dorsal fascia, and the superficial transverse ligament of the toes, all are similar to their homologues in the upper limb, but the last named connects five digits, instead of only four. The tendons of the toes are kept in place by fibrous bands, and are provided with synovial membranes, as are the corresponding organs in the hand.

SYNOVIAL BURSÆ.

The structure of bursal synovial membranes (*bursæ synoviales*) has already been presented (page 71). It is not desirable to give in this place a detailed description or even to make mention of all of these organs that have been found; for of the great number, many are insignificant, and others are so rare as to be merely curiosities. It will suffice to indicate the situation, relations, and connections of those which are constant or even common, and those which have especial physiologic or clinical importance. Of the bursæ infrequently seen, some are found only in those persons in whom some peculiar, localized stress has provoked their development from open spaces in areolar tissue. Illustrations of this are encountered over the spine of the scapula in individuals who carry burdens on the shoulder; over the xiphoid process, and between the rectus femoris and the vasti in shoemakers; and over the angle between the first and second pieces of the sternum in carpenters and cabinet-makers.

It should be understood that the bursæ mentioned in the following enumeration are not all constant, but that any particular one of the inconstant may be found in any case. The initial letter of "bursa" will be used instead of the full word in giving the Latin name.

B. trapezii is situated between the trapezius and the triangular surface at the base of the spine of the scapula.

B. acromialis subcutanea lies between the skin and the acromion process.

B. subacromialis is located between the capsular ligament of the shoulder and the arch made by the coracoid and acromion processes, and extends beneath the deltoid muscle, from which fact it is often called *B. subdeltoidea.*

B. coraco-clavicularis media is found between the conoid and trapezoid ligaments.

B. pectoralis majoris separates the tendon of the greater pectoral muscle from the *B. intertubercularis* and the latissimus. The latter bursa is the prolongation of the articular synovial membrane of the shoulder, which invests the tendon of the long head of the biceps.

B. coracobrachialis is situated between the coracobrachialis and the biceps on one side, and the subscapularis on the other.

B. latissimi lies between the latissimus and teres major. Sometimes a bursa is found between the latissimus and the lower angle of the scapula.

B. teretis majoris is lodged between the tendon of insertion of the teres major and the small tuberosity of the humerus.

B. subscapularis, between the subscapularis and the neck of the scapula, is really a diverticulum of the synovial membrane of the shoulder-joint.

B. epicondyli externi subcutanea and *B. epicondyli interni subcutanea* lie upon the external and internal condyles of the humerus respectively.

B. bicipito-radialis, often double, is situated between the tuberosity of the radius and the tendon of the biceps, which is inserted into it. At the inner side of this bursa and its associated tendon is sometimes found the *B. ulno-radialis* (*B. cubitalis interossea*), close to the ulna and the muscles of the neighborhood.

B. olecrani subcutanea covers the dorsal surface of the olecranon process.

B. olecrani subtendinea is located above the olecranon, in front of the triceps, and behind the posterior ligament of the elbow-joint.

B. anconei is between the anconeus and the elbow-joint.

B. extensoris carpi radialis brevis is placed beneath the tendon of insertion of the muscle named. A bursa is less often found in the same relation to the long radial extensor of the wrist.

B. extensoris carpi ulnaris is situated beneath the origin of the ulnar extensor of the wrist, and may communicate with the elbow-joint.

B. capitulæ ulnæ subcutanea lies beneath the skin over the styloid process of the ulna.

B. sacralis is found upon the spinous process of the fourth sacral vertebra, or over the joint between the sacrum and the coccyx.

B. subiliaca is located behind the united tendons of the iliacus and psoas muscles and in front of the capsular ligament of the hip-joint, with the cavity of which it is often connected.

B. trochanterica subcutanea is situated under the integument which covers the great trochanter.

B. trochanterica profunda is placed between the outer surface of the great trochanter and the upper part of the tendon of insertion of the gluteus maximus.

B. glutei maximi ischiadica is found between the tuberosity of the ischium and the lower border of the muscle named.

B. glutei medii anterior lies between the anterior part of the tendon of the middle gluteal muscle and the great trochanter.

B. glutei medii posterior intervenes between the hind part of the tendon of this muscle and the pyriformis.

B. glutei minimi is between the tendon of insertion of this muscle and the anterior surface of the great trochanter.

B. pyriformis is placed either between the tendon of this muscle and the gemellus superior, or beneath its tendon of insertion.

B. obturatoris interni is situated between the tendons of the internal obturator and the gemelli, and may communicate with the B. ischiadica. There is also a bursa in the small sciatic notch, over which the obturator internus glides.

B. pectinei has on one side the insertion of the pectineus, and on the other the lowest part of the iliacus and the adjacent surface of the femur.

B. semitendinoso-bicipitalis lies between the united tendons of origin of the semitendinosus and biceps flexor cruris and the tuberosity of the ischium.

B. sartorii separates the sartorius from the inner tuberosity of the tibia, and from the tendons of the gracilis and semitendinosus.

B. semimembranosi, often double, is situated between the tendons of the semimembranosus and quadratus femoris. Another bursa lies between the expansion of the tendon of insertion of the semimembranosus and the inner tuberosity of the tibia.

B. tibialis interna (B. anserina) is placed between the lower part of the inner hamstring tendons and the internal lateral ligament of the knee. This bursa may connect with the knee-joint through the B. gastrocnemii interna.

B. bicipitis cruris (B. fibularis) is lodged between the tendon of insertion of the biceps of the leg and the external lateral ligament of the knee, and may communicate with the joint.

B. poplitei has the tendon of origin of the popliteus on one surface and on the other the external tuberosity of the tibia and the capsule of the knee. It always connects with the joint-cavity, of which it may be considered a diverticulum, and sometimes communicates with the superior tibio-fibular articulation.

B. supra-acetabularis lies between the reflected tendon of origin of the rectus femoris and the upper margin of the acetabulum.

B. suprapatellaris is situated between the quadriceps extensor cruris and the lower part of the anterior surface of the femur. Its cavity communicates with that of the knee-joint.

B. prepatellaris subcutanea is located on the anterior surface of the patella, just beneath the skin.

B. infrapatellaris is placed between the ligamentum patellæ and the anterior surface of the head of the tibia.

B. condyli externi and *B. condyli interni*. One is found between the external condyle of the femur and the skin, the other in similar relation to the internal condyle.

B. pretibialis lies between the tubercle of the tibia and the superjacent fascia.

B. gastrocnemii interna is situated behind the inner condyle of the femur and

the capsule of the knee-joint, between the inner head of the gastrocnemius and the semimembranosus. It communicates with the joint.

B. postcalcanea superficialis is found between the tendo calcaneus (Achillis) and the deep fascia.

B. postcalcanea profunda (B. tendinis calcanei) is placed between the tendo calcaneus and the posterior surface of the os calcis.

B. subcalcanea lies between the inferior surface of the calcaneum and the plantar fascia.

B. malleoli externi subcutanea is located under the skin which covers the external malleolus. The internal malleolus is provided with a similar bursa—*B. malleoli interni subcutanea.*

B. tibialis anterioris is lodged between the distal tendon of the muscle named and the internal cuneiform bone.

B. sinus tarsi is lodged between the fascia binding down the extensor longus digitorum and the head of the astragalus.

B. prementalis is situated beneath the skin at lower margin of the symphysis menti.

B. musculi trochlearis is in the pulley of the superior oblique muscle of the eyeball.

B. coccygea lies between the free end of the coccyx and the sphincter ani.

B. prominentiæ laryngeæ subcutanea occurs principally in the aged between the skin and the upper part of the thyroid cartilage.

THE BLOOD-VASCULAR SYSTEM.

THE *blood* is the vehicle by which nourishing materials are carried to the tissues, and many effete substances conveyed away from them. It is contained in a continuous series of chambers and tubes, which constitute the blood-vascular system. The chambers are the compartments of the heart, and the tubes are the arteries, the capillaries, and the veins—including under the last term not only the veins proper, but also certain channels which are called venous sinuses. The *arteries* are the vessels which carry blood *from the heart* to the tissues; the *capillaries* are those through whose delicate walls the interchange of nutrient and waste matters takes place *in the midst of the tissues*; and the *veins* are the vessels which convey the blood from the tissues *to the heart.* The whole blood-vascular system is closed in the normal condition, and no blood escapes from it, with two exceptions, which are as follows: in the female, during the child-bearing portion of her life, there is a periodical discharge of blood through ruptured vessels; and in the spleen of all persons the blood leaves the minute vessels, and flows through wall-less tubes in the parenchyma of the organ.

In the entire blood-vascular system *one structural feature is constant*—the serous membrane which lines it. Muscular and fibrous coats in most parts are found surrounding the serous, but they are not, like it, invariable. The importance of this smoothest of all membranes as a lining for the heart and vessels is appreciated, when we consider that any roughness of a surface over which blood flows causes clotting of the fluid, and this results in the plugging of vessels, and the consequent starvation of the parts which they should supply with blood.

THE HEART.

By F. H. GERRISH.

THE *heart* (Latin *cor*, or *cardia*) is the central organ of the vascular system. It is the force-pump which propels the blood through the vessels. In some animals it has but one cavity, in others it has two, in still others three. In man there are really two hearts, each having two chambers. The two hearts in the adult may be compared to a block of two houses, which are independent of each other except for the fact that the partition wall between them is common to both. During intrauterine life there is a door of communication between the upper chamber of one and the corresponding cavity of the other; but this is closed at birth, and thenceforward the blood cannot get from one side to the other without leaving the heart and going by a roundabout path.

These two hearts are called, on the basis of their independence, the *right heart* and the *left heart* respectively; on the ground of their union, they are named the right side of the heart and the left side of the heart respectively. Both sets of designations are misleading as regards the relative situation of the two organs (or sides of the same organ), for they are not placed right and left, but one—the right—is in front of the other. One chamber of each is called *auricle*, because of the resemblance of an appendage of it to an animal's external ear; the other chamber is named *ventricle*, from its bulging like a prominent abdomen. The

auricles are spoken of as if they were entirely on a higher level than the ventricles, whereas they are nearly on the same plane.

Each auricle receives blood from veins, and delivers it to the corresponding ventricle, which then discharges it through an artery.

The Circulation of the Blood.

The course of the blood is as follows (Fig. 445): Beginning in the auricle of the right side, the blood, which has just come from the tissues of the entire body, passes through the large aperture by which the auricle communicates with its ventricle, and which is called the right auriculo-ventricular opening; from the right ventricle it is driven through the pulmonary artery to the lungs, through the walls of whose capillaries it loses certain impurities and gains oxygen from the air, thus being changed from venous blood to arterial; from the lungs it flows through the pulmonary veins to the left auricle, thence through the left auriculo-ventricular opening to the left ventricle, whence it is forced into the aorta, the great trunk of the general arterial system, and by this and its branches it is distributed throughout the body. From the twigs of the arterial system the blood is poured into the capillaries, and here parts with nourishing materials, synchronously receiving a load of effete substances, in this way being altered from arterial to venous. From the capillaries it courses into the veins, which conduct it to the right auricle, the place from which the reckoning began. This description of the track of the blood confirms the statement previously made that the communication between the right and left sides of the heart is not direct, through the partition wall, but is entirely indirect—it being necessary for the blood to go out of the heart and through the capillaries of some organ in order to get from either side to the other.

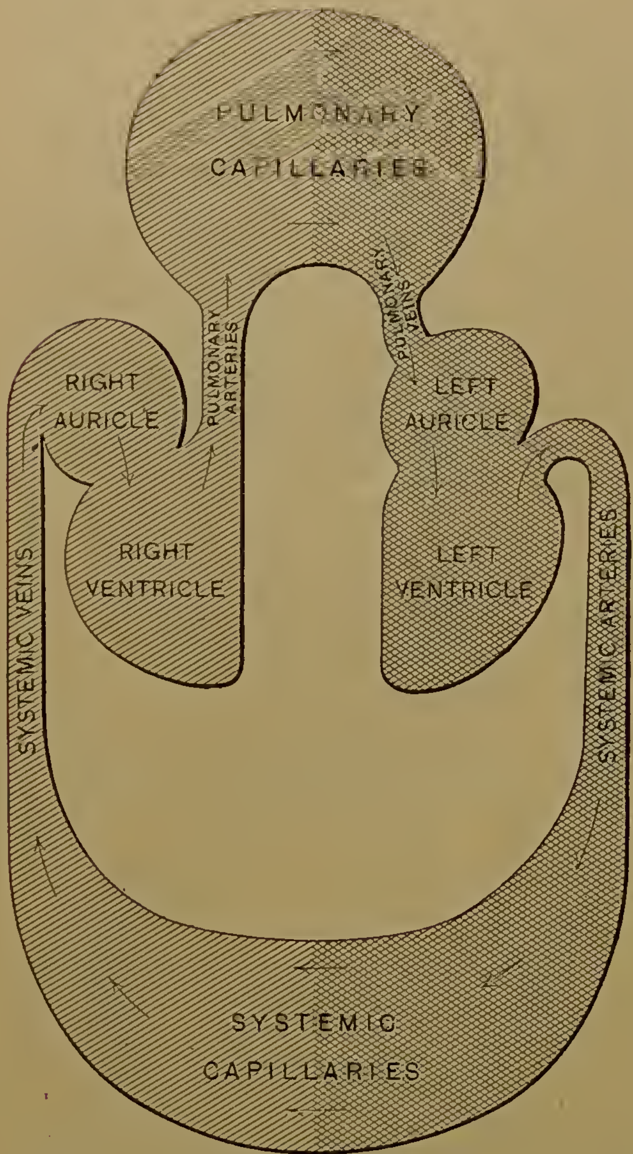


FIG. 445.—Diagram to show the course of the blood in passing from a given point through the two sets of capillaries to the starting point. (F. H. G.)

The journey of the blood from the right heart to the left through the capillaries of the lungs is the less or *pulmonary circulation*; and the passage of the blood from the left heart to the right through the capillaries of the organs of the body is the great or *systemic circulation*. It is to be noted that, in going through the lung-capillaries, the blood is changed from venous to arterial; and that, in its course through the capillaries of the general system, the reverse occurs—it is altered from arterial to venous. The kind of blood contained in a vessel does not, however, make the latter either vein or artery, as the pulmonary artery bears foul or venous blood, and the pulmonary veins are full of purified or arterial blood. *Arteries* carry blood, red or blue, *from the heart*; *veins* carry blood, blue or red, *to the heart*.

The Tissues of the Heart.—The lining of the heart, like that of all other parts of the vascular system, is serous membrane, and is called *endocardium* ("within the heart"). The outer covering, too, is serous, and is called *pericardium* ("around the heart"). It will be described in detail on a subsequent page.

Between the endocardium and the pericardium is a middle coat, which is muscular and fibrous, and, on account of the enormous preponderance of the contractile tissue, is named *myocardium* ("muscle of the heart"). The muscular tissue is of the cardiac variety. The arrangement of the bundles of fibres is extremely intricate, and not yet fully understood in all of its details.

The Thickness of the Cardiac Walls.—The muscular walls of the right auricle are thin and so flabby that they fall together when the cavity is empty; they have to drive the blood but a short distance—only into the ventricle—and through a very large opening. The right ventricle has thick, firm walls, so powerful that by them the blood is sent through the pulmonary artery and its branches, into and through the numberless capillaries of the lungs, through the pulmonary veins, and into the left heart. The left auricle has walls but little thicker than those of the right, yet quite equal to the trifling labor placed upon them—that of forcing the blood through the large auriculo-ventricular orifice into the left ventricle. The left ventricle by its contraction must drive the blood through the vessels of the systemic circulation; and, as these are much more numerous than those of the pulmonary set, and present, on account of their situation, far greater frictional resistance to the passage of the blood in proportion to their number, there is necessity for vastly greater power in the ventricular walls, which, in fact, are three times as thick as those of the right ventricle (Fig. 446). The bulging of the interventricular septum into the right ventricle is due to this greater thickness of the parietes of the left; indeed, this whole partition has the appearance of being formed by the latter.

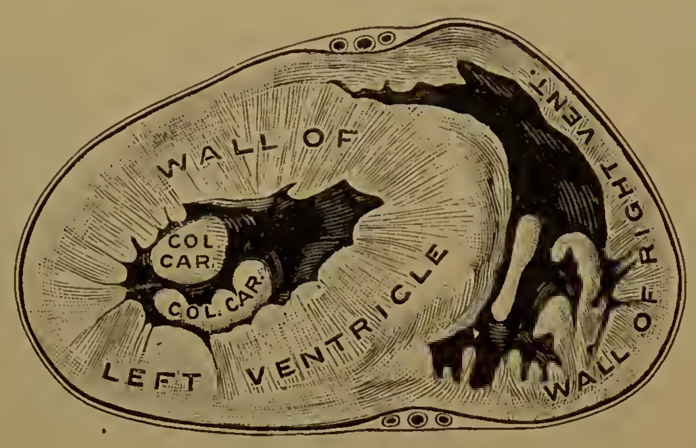


FIG. 446.—Cross-section through both ventricles, showing the shape of their cavities and the relative thickness of their walls. (Testut.)

The auriculo-ventricular openings and those of the pulmonary artery and the aorta are guarded by valves, which do not interfere with the passage of the blood in the course already described, but do serve to prevent a return of blood to a cavity from which it has been discharged.

The heart is situated in the lower part of the chest, toward the front, extending much farther to the left side than to the right. It lies obliquely, the auricles being at the right of and a little higher than the ventricles. The details of its situation will be given a little later.

The Right Auricle (Fig. 447), when viewed from the inside, presents a main chamber, the *atrium* ("hall"), and a little ante-chamber, the cavity of the *auricular appendix*, the latter being at the front and upper part of the auricle. A number of openings are seen. At the back the two *venæ cavæ* enter, the superior above, the inferior below. The floor of the atrium is largely formed by a trapdoor, the tricuspid valve, which closes the oval *auriculo-ventricular opening.* Several *cardiac veins* of considerable size, returning blood from the substance of the heart itself, open directly into the cavity. The largest of these is called the *coronary sinus*, and enters between the inferior vena cava and the auriculo-ventricular orifice, its orifice being protected by a serous fold, the valve of Thebesius. There are also some very small veins, *venæ minimæ cordis* ("the least veins of the heart"), whose apertures, together with others of similar appearance, which are said to be blind depressions, have been named *foramina Thebesii* ("holes of Thebesius"). On the hind wall, which is the partition between the two auricles, is a shallow depression, the *fossa ovalis* ("oval pit"), bordered, except below, by a ridge, the *annulus ovalis* ("oval ring"). The fossa marks the site of a hole (*foramen ovale*), which exists in the *septum auricularum* ("partition of the auricles") in intrauterine life, and at birth becomes permanently closed by a flap of membrane. Various projections from the surface are observed, some

being muscular, others merely folds of endocardium. A network of muscular ridges covers the wall of the appendix, and on the right wall of the atrium is a series of vertical bands of nearly equal size, not inaptly named *musculi pectinati* ("comb-like muscles"). Connecting the margin of the inferior vena cava and the anterior edge of the annulus ovalis is a membranous fold, the *Eustachian valve,* which is prominent in proportion to the youth of the individual. In the fœtus it serves to guide the blood from the inferior vena cava through the foramen ovale of the septum into the left auricle. Between the openings of the venæ cavæ is an indistinct projection, the tubercle of Lower.

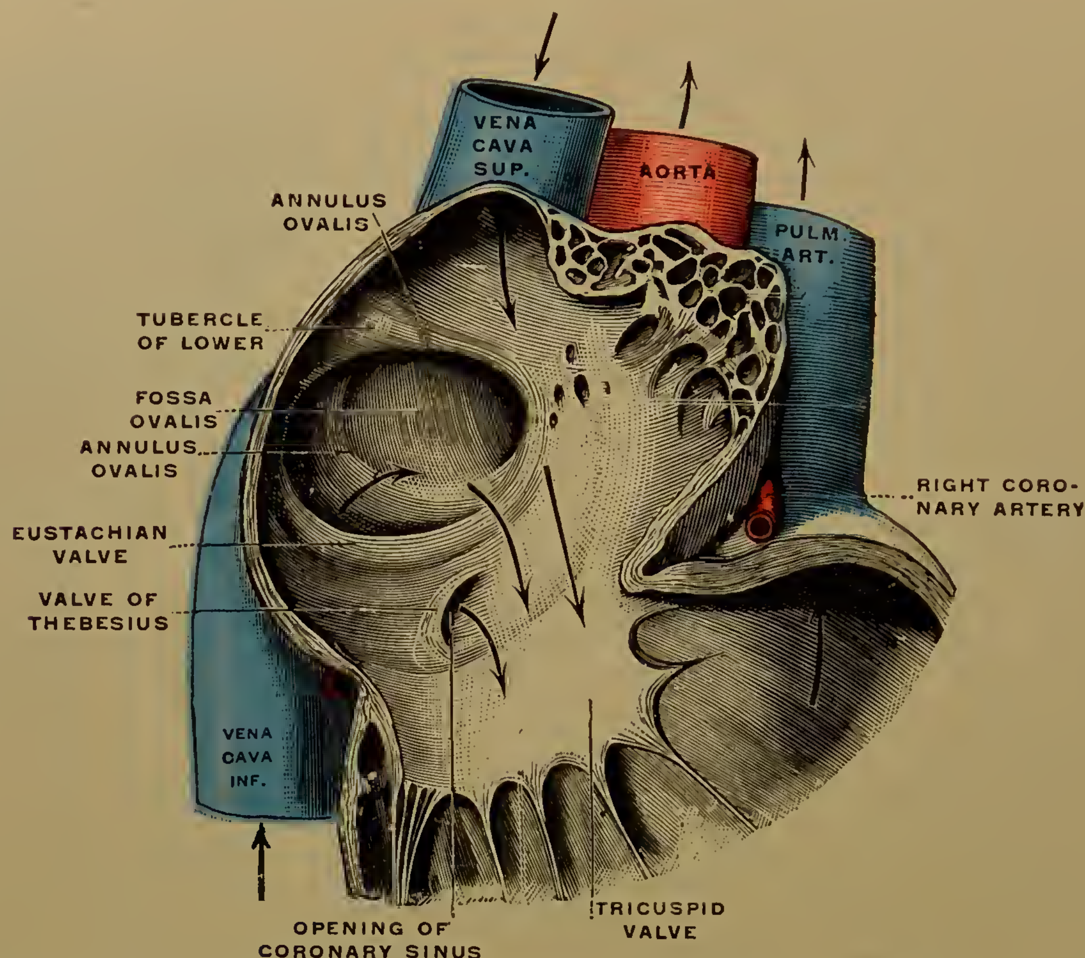


FIG. 447.—Right auricle and part of right ventricle, the front wall having been removed. The auricular appendix projects above at the right. The arrows indicate the direction of the blood-current. (Testut.)

The Right Ventricle has an irregular cavity, its wall being concave in front and convex behind, where the *septum ventriculorum* ("partition of the ventricles") presents. There are two large openings—the *auriculo-ventricular orifice,* and that of the *pulmonary artery,* the latter being at the apex of the *infundibulum,* a somewhat funnel-shaped portion of the chamber toward the left side. The auriculo-ventricular opening is closed by the *tricuspid valve,* so called from its three conspicuous segments. These are of unequal size and irregular shape, having ragged and frayed free edges, and between their attached borders frequently small secondary segments. One flap is at the left, one at the right, and one behind. They are composed of white fibrous tissue, and their attached borders are united to a fibrous ring, which encircles the orifice. At the junction of the pulmonary artery with the heart is the *pulmonary valve,* made up of three fibrous festoons of semilunar shape (Fig. 451). The free edge of each is marked at its middle by a nodule, the *corpus Arantii* ("body of Arantius"). The attached margin is strengthened by a ring of fibrous tissue. Behind each flap is an enlargement of the arterial bore, making a little recess, the *sinus of Valsalva.* Many large muscular prominences, *columnæ carneæ* ("fleshy columns"), are observed everywhere, except in the infundibulum (Fig. 448). Of these there are three kinds: those that are sculptured in high relief from the wall—attached at both ends and all of one side; those that are fastened at both ends and nowhere else; and those that have only one extremity secured to the wall. The last are known as *papillary muscles,* because they stand out like nipples, and they are arranged in two princi-

pal sets, anterior and posterior. From their summits project delicate tendons, *chordæ tendineæ*, which are inserted into the free edges and under sides of the flaps of the tricuspid valve. Running across the chamber obliquely is usually a prominent muscular beam, the *moderator band*.

Action.—When the muscular wall of the ventricle contracts, the cavity is practically obliterated, and its contents are discharged. As soon as contraction begins, the tricuspid valve is closed, and, were it not for the special restraining apparatus, its flaps would be swept into the auricle, and the greater part of the blood in the ventricle would go with them. But the papillary muscles come into action simultaneously with all other parts of the wall, and pull the valve downward exactly to the extent that the blood tends to push it upward beyond the plane at which the free margins of its segments come in close contact. Thus regurgitation is prevented, and the blood is forced through the only other avenue of escape, the pulmonary artery. The contraction of the ventricle ceasing, the distended artery has a tendency to return some of its contents to the ventricle; but, as soon as the column of fluid starts backward, the semilunar festoons, which have been flattened by the outrush of blood from the heart, are closed with a snap, the accumulation in the sinuses behind them giving the first impulse, and the pressure of the fluid in the artery completing the act. In this way not a drop is allowed to regurgitate. The columnæ carneæ of the first and second varieties are useful in regulating contraction and evenly distributing pressure, the moderator band being of especial service in preventing too great distention and in causing approximation of the opposite walls.

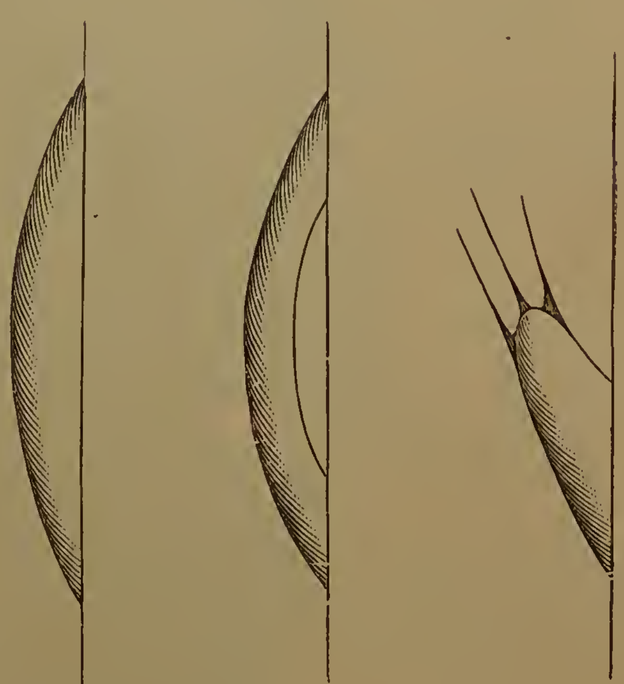


FIG. 448.—The three varieties of columnæ carneæ. (F. H. G.)

The Left Auricle presents fewer irregularities of internal surface than does the right (Fig. 449). The *musculi pectinati* are less numerous and less pronounced. Toward the rear on each side are the orifices of two *pulmonary veins*. The position of the fœtal foramen ovale is indicated by a slight indentation on the septal wall. The *auriculo-ventricular opening* is much like that in the right heart, but a little smaller. It is guarded by the bicuspid valve.

The Left Ventricle has a capacity equal to that of the right, but its cavity has a different shape, being ovoidal. In general features it strongly resembles the other ventricle. The three varieties of *columnæ carneæ* are present; but, while these muscular bundles are more numerous, they are of less size. The *papillary muscles* are disposed in two series. A band, similar to the moderator of the right ventricle, but much smaller, crosses the chamber. At the uppermost part of the septum anteriorly the wall is fibrous and very thin, constituting a weak area, sometimes called the *undefended space*. The auriculo-ventricular orifice and that of the aorta are very close together, the former being toward the rear, the latter near the front. The *auriculo-ventricular valve* is called *bicuspid*, on account of its having two chief segments, and *mitral*, because these flaps, when open, are somewhat suggestive of a bishop's mitre (Fig. 450). One segment lies close to the hind wall, the other and larger is between the two orifices. Frequently small secondary segments are found between the two great flaps. The valve is connected with papillary muscles by *chordæ tendineæ*, and in general features of structure is like the tricuspid, already described. The valve at the base of the aorta (Fig. 451) is a repetition of that of the pulmonary artery, except that in almost every respect its characteristics are more pronounced. The semilunar segments are situated

respectively in front, at the left behind, and at the right behind. From the sinus of the first of these is given off the *right* (anterior) *coronary artery*, and from that of the second the *left* (posterior) *coronary artery* springs. These vessels are

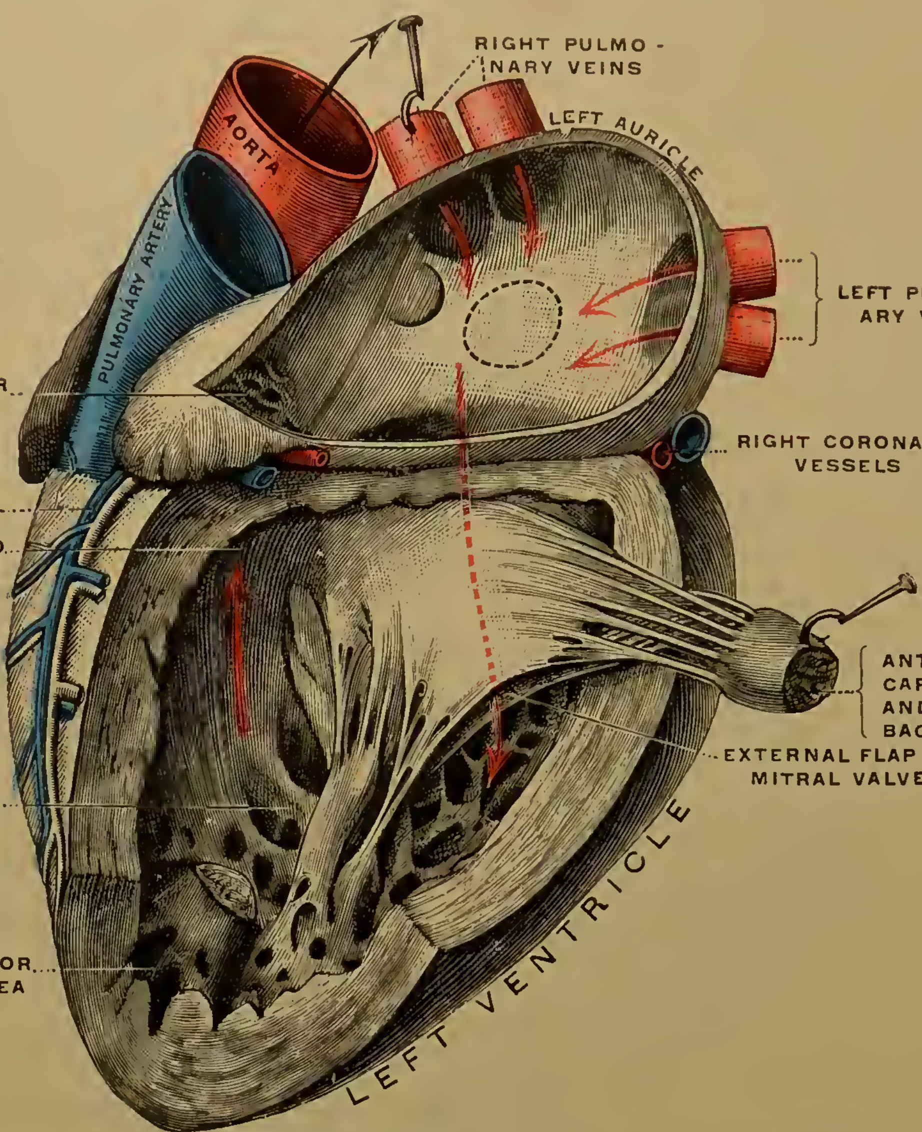


FIG. 449.—Left auricle and ventricle, the hind wall of each having been removed. (Testut.)

called coronary because they encircle the heart like the band of a crown. They are the first branches of the aorta, and feed the heart. Between the auriculo-

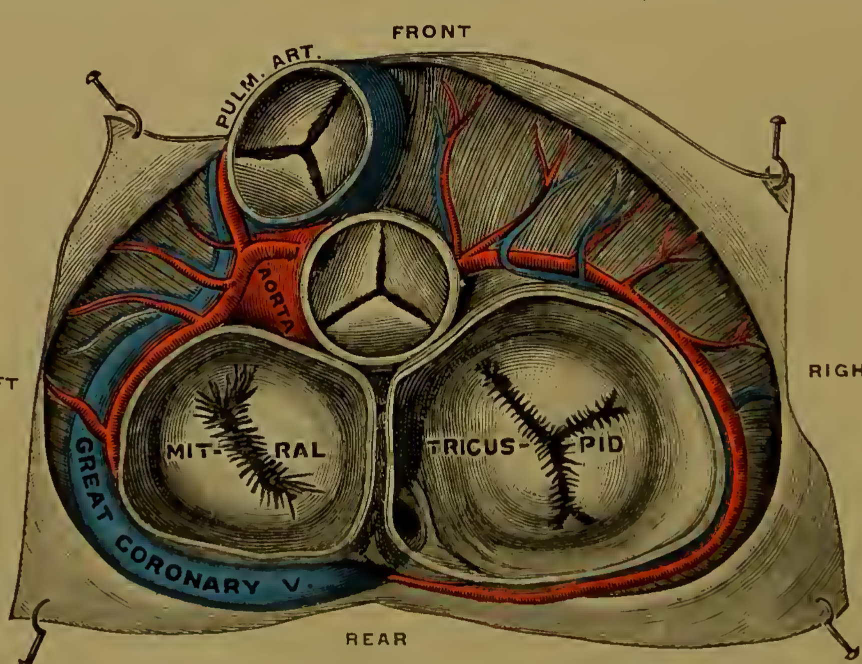


FIG. 450.—Valves of the heart and great arteries, viewed from above, the auricles having been removed. (Testut.)

ventricular and aortic orifices is a mass of mingled white fibrous tissue and white fibro-cartilage, from which are given off fibrous prolongations forming rings around the openings, and so stiffening their margins that stretching is prevented.

The *bulk* of the heart has been said to be approximately that of the fist of its owner; but to this rough-and-ready rule there are so many exceptions as to render it of little value. During life the diameters of the heart are constantly changing, and measurements made after death may be misleading. Its average length is about five inches, its width three and a half, and its thickness two and a half. It increases in weight and volume with rather unsteady progression to the end of life. Its average *weight* in the male is about eleven ounces; in the female it is somewhat less. Its *blood-vessels* are the coronary arteries and veins. It has numerous lymphatics. The *nerve-supply* is derived from the pneumogastric and from fibres of the cervical and thoracic ganglia of the sympathetic.

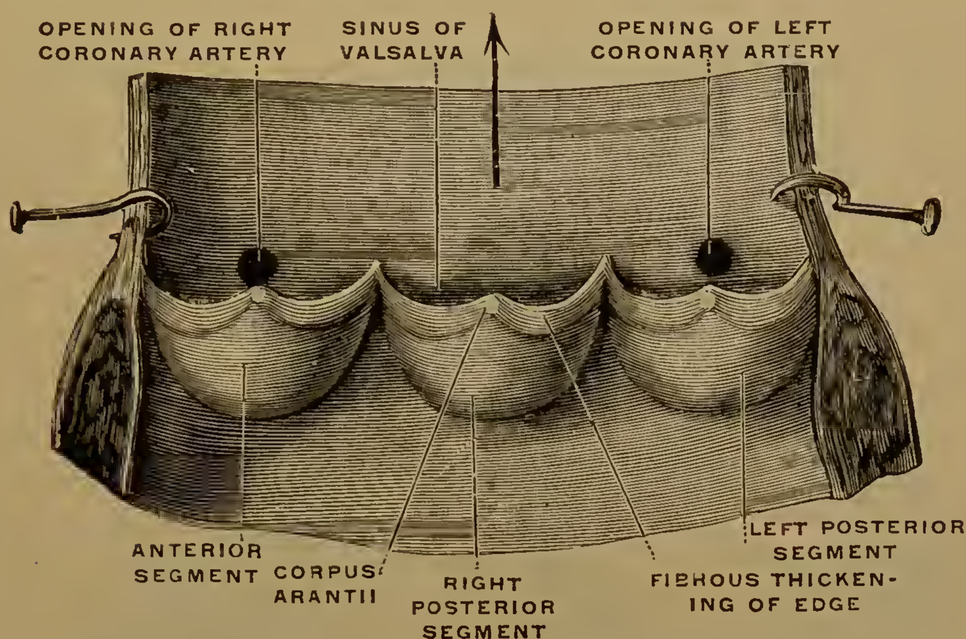


FIG. 451.—Aortic valve. The artery has been cut open between the anterior and left posterior segments, and spread out. (Testut.)

The External Configuration of the Heart.

The Grooves of the Heart.—The surface of the heart is marked by a series of grooves, which indicate the superficial limits of the various cavities.

Between the auricles and ventricles is the *auriculo-ventricular groove*, which is incomplete in front, where the anterior surface of the pulmonary artery is continuous with that of the right ventricle. This vessel occupies the broad ventral depression between the auricles—the *anterior interauricular groove*. The *posterior interauricular groove* lies between the right pulmonary veins and the portion of the right auricle which connects the superior and inferior venæ cavæ.

Between the ventricles are the interventricular grooves, which are continuous at the right of the apex of the heart. The *anterior interventricular groove* begins between the pulmonary artery and the left auricular appendix, and runs downward upon the ventral surface of the heart. The *posterior interventricular groove* starts at the left of the inferior vena cava, almost in continuation of the posterior interauricular groove, and courses forward upon the inferior surface of the organ. The grooves are occupied by vessels, embedded in adipose tissue.

The Surfaces of the Heart.—When the heart has been hardened while maintaining its natural relations with contiguous organs, it presents six surfaces, separated from one another by borders, which are defined with varying degrees of distinctness.

The Ventral Surface (Fig. 452) is slightly convex, irregularly quadrilateral, and looks forward and a little upward. It presents the front of the right ventricle, a part of the right auricle, of both appendixes, and of the left ventricle. The right (anterior) coronary artery is seen in the right auriculo-ventricular groove, giving off branches, of which the principal are the preventricular above, and the right (anterior) marginal below, the latter running to the left near the lower border. The anterior interventricular groove lodges a branch of the left (posterior) coronary artery and the great coronary vein. The ventral surface is

bounded by the ill-defined *right border*, which falls upon the convex surface of the right auricle ; below by the *antero-inferior border*, which separates it from the inferior surface, and is so sharp that it is called *margo acutus* ; on the left by the *left border*, on the marked convexity of the left ventricle ; and above by the line of junction of the pulmonary artery with the heart, and by the upper margin of the appendixes.

The Dorsal Surface (Fig. 453) is irregularly convex, looks backward, and presents the greater part of the left auricle. Above are the horizontally directed primary divisions of the pulmonary artery, the right and left pulmonary arteries ; at the right the posterior interauricular groove ; below, the auriculo-ventricular

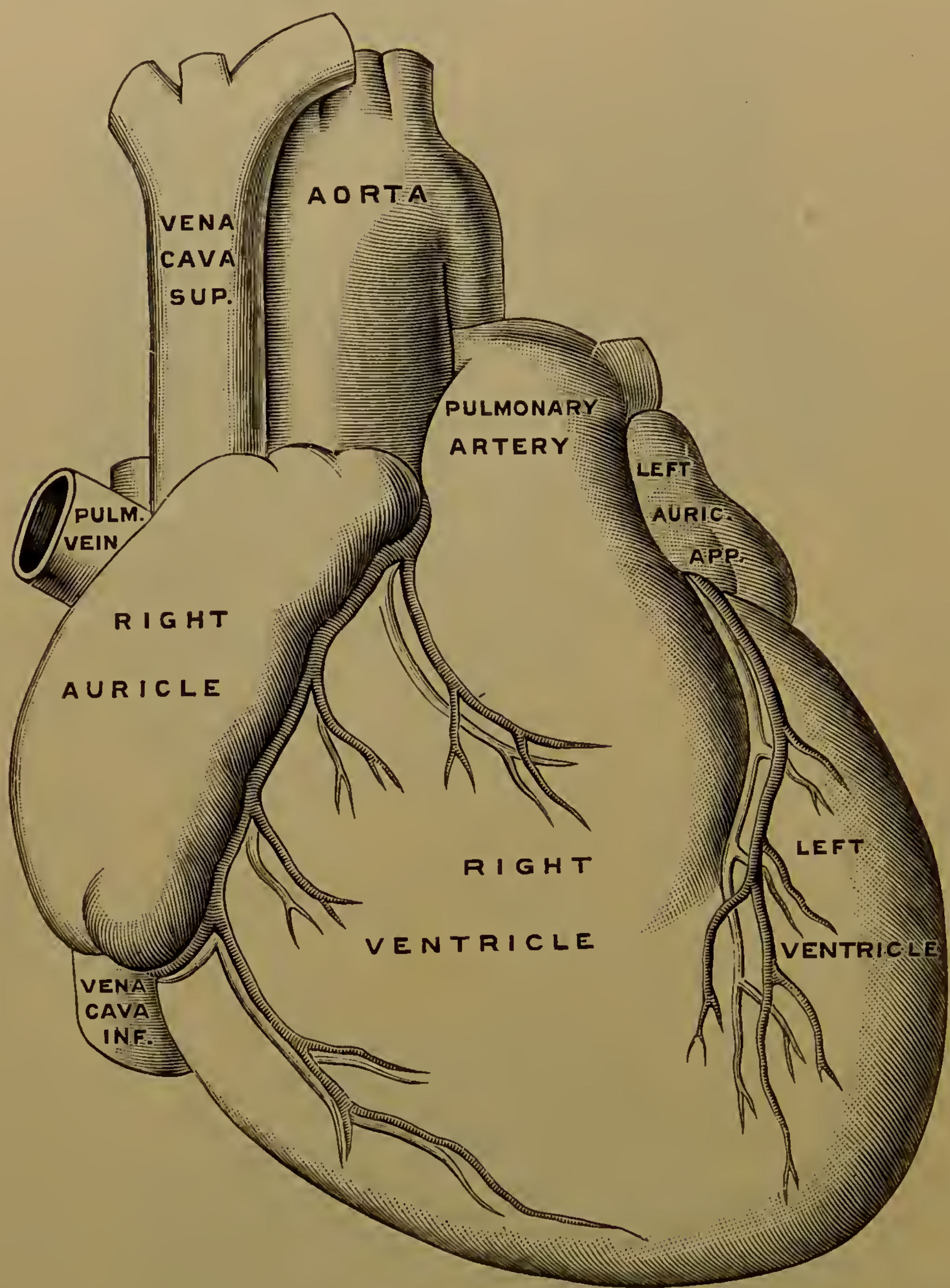


Fig. 452.—Front view of the heart. The auriculo-ventricular and anterior interventricular grooves and the vessels in them are not labelled, but cannot be mistaken. (From the His cast. F. H. G.)

groove ; at the left a line leading downward from the left pulmonary veins, commonly marked by the oblique vein (of Marshall), which ends below in the coronary sinus.

The Right Surface is convex, quadrilateral, and exhibits nearly all of the right auricle which is not included in the ventral surface. At the postero-inferior angle the vena cava inferior enters, and the vena cava superior is seen above. Behind is the posterior interauricular groove ; below, the auriculo-ventricular groove ; and in front is the right border, already mentioned.

The Left Surface is unevenly convex and somewhat triangular. It presents above and behind a part of the left auricle, and in front of this a portion of its appendix ; below, the left ventricle, tapering to the apex, and showing in the

midst of this space the marginal branch of the left coronary artery and the left marginal vein; and, between the auricle and ventricle, the great coronary vein.

The Inferior Surface is nearly flat, and looks downward and backward, conforming to the sloping upper surface of the anterior portion of the diaphragm. Here are seen parts of both ventricles, separated by the posterior interventricular groove, which lodges the interventricular branch of the right coronary artery and the middle cardiac vein; and at the back and right a small part of the right auricle and the aperture of entrance of the vena cava inferior.

The Upper Surface is small and irregular, and is occupied by the great vessels which form the bulk of the stem of the heart—the pulmonary artery, the aorta, and the vena cava superior.

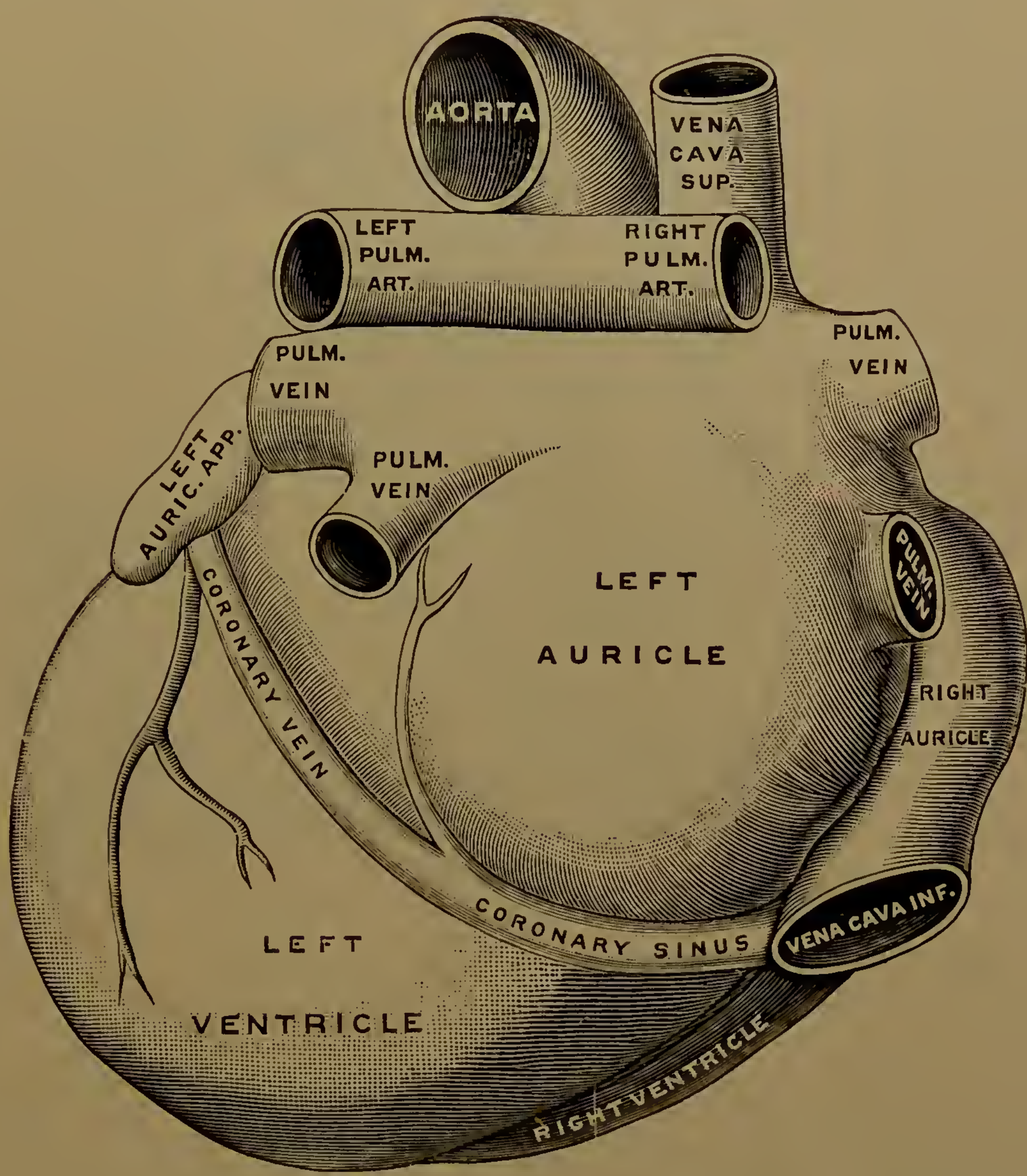


FIG. 453.—Rear view of the heart, showing the dorsal and inferior surfaces. (Modified from the His cast. F. H. G.)

The ventral, inferior, and left surfaces converge at the left anterior portion of the heart to a blunted point, called *the apex*. This is constituted entirely by the left ventricle, owing to the fact that the wall of this chamber is very much thicker than that of the right ventricle. The apex lies behind the space between the fifth and sixth costal cartilages, about three and a half inches from the middle line.

THE PERICARDIUM.

The *pericardium* ("around the heart") is the sac in which the heart is contained (Fig. 454). It consists of two parts: (1) an external, fibrous portion, and (2) an internal, serous portion.

The *fibrous bag*, composed mostly of white fibrous tissue, somewhat loosely encloses the heart, and is attached to various structures in the immediate neighborhood. Inferiorly it is firmly adherent to the diaphragm, with whose central

tendon its fibres are intermingled. It extends upward onto the great vessels for two inches or more, blending with their sheaths; and in this region it is also continuous with a downward prolongation of the cervical fascia. In front it is connected with the breast-bone by two fibrous bands, the *superior* and *inferior sterno-pericardial ligaments*; and the parietal pleuræ are adherent to its lateral surfaces.

The *serous membrane* furnishes a lining to the fibrous bag, and is thence reflected onto the contained organs, giving them a closely attached covering. The lining of the fibrous pouch is the parietal portion of the serous membrane, and

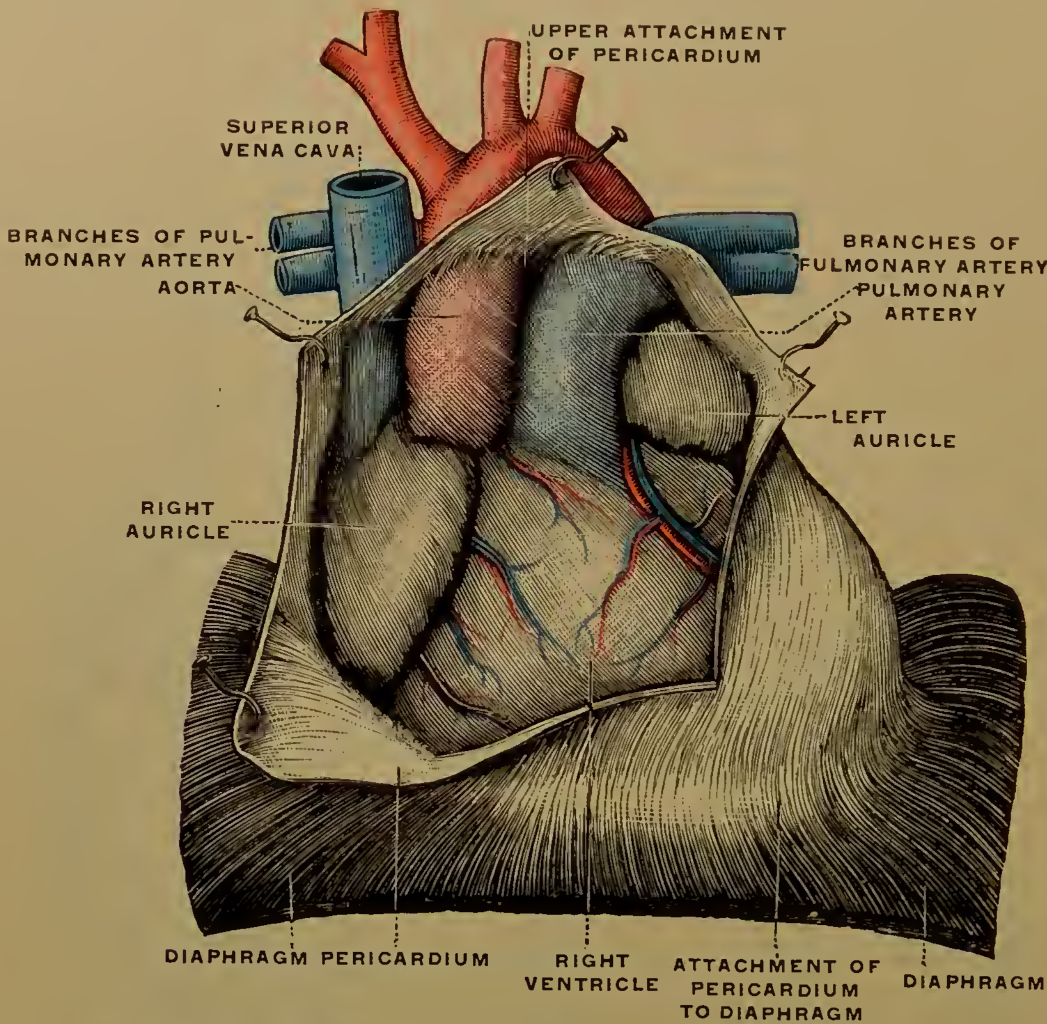


FIG. 454.—The heart *in situ*. The pericardium has been cut open in front, and reflected. (Testut.)

the clothing of the heart and vessels is the visceral portion, the latter sometimes being called the *epicardium* ("upon the heart"). Thus, the heart, which changes its position seventy times a minute all through life, is enabled to move with the least possible friction.

The pericardium does not completely encase all of the vessels attached to the heart. The aorta and pulmonary artery are enclosed in one sheath, the others are only partially covered. Many pouches of pericardium are found between the vessels at the lines of reflection of the membrane.

The *arteries* which supply the pericardium are the internal mammary, phrenic, pericardiac, œsophageal, and bronchial. Its *nerve-supply* comes from the pneumogastric, phrenic, and sympathetic.

THE SITUATION AND RELATIONS OF THE HEART.

The cavity of the thorax is divided into three unequal parts—two lateral, which are occupied respectively by the right and left lungs, each enveloped in its serous coat, the pleura; and a part between these, in which are lodged the remaining thoracic organs. This third portion is called the *Mediastinum* ("standing in the middle"). Ventro-dorsally the mediastinum extends between the

sternum and the vertebral column, laterally from the mesial surface of one pleura to that of the other, and vertically from the diaphragm to the upper opening of the thoracic cage, which aperture is outlined by the top of the sternum, the first ribs, and the first thoracic vertebra. The part of this space above the pericardium is the *superior mediastinum*, that in front of the pericardium is the *anterior mediastinum*, that behind the pericardium is the *posterior mediastinum*, and that occupied by the pericardium and its contents is the *middle mediastinum.* The pericardium is so close to the front wall of the chest that the anterior mediastinum has but little ventro-dorsal depth, and it contains no organs of much practical importance; but the superior and posterior mediastina hold the principal parts of many organs of the greatest moment, of which the chief are the trachea, the œsophagus, the great vessels connected with the heart, the vagus and other nerves, and the thoracic duct.

Enclosed in the pericardium the heart lies upon the diaphragm, fully two-thirds of its volume being to the left of the median plane of the body. Its base is directed to the right, upward and backward, its apex to the left downward and forward.

Its position with reference to the front wall of the thorax may be mapped out as follows: the apex being behind the fifth intercostal space, $3\frac{1}{4}$ or $3\frac{1}{2}$ inches from the middle plane, a line somewhat convex downward, drawn from this spot to the articulation of the seventh right costal cartilage with the sternum indicates its lower limit; a line drawn at the level of the upper border of the third costal cartilages from a point half an inch from the sternum at the right to a point an inch from the sternum on the left marks the upper limit; the dextral boundary is shown by a line convex to the right, connecting the right ends of these lines; and the remaining side of the figure is made by uniting the left extremities of the upper and lower lines by one that is somewhat convex to the left.

The *pulmonary valve* is behind the junction of the third left costal cartilage and the sternum; the *aortic valve* is behind the mesial end of the third left inter-costal space; the *mitral valve* is behind the fourth left costal cartilage and the adjacent part of the sternum; the *tricuspid valve* is behind the middle line of the sternum, opposite the fourth intercostal space. The pulmonary value is the most superficial, the mitral the farthest from the surface.

The heart, enclosed in the pericardium, has *below* it the diaphragm; *in front*, between it and the sternum, the remains of the thymus gland, the anterior margin of the lungs with their pleuræ, the triangularis sterni muscle, the sterno-pericardial ligaments, the internal mammary vessels, and some areolar tissue; *above*, the great vessels; *laterally*, the lungs in their pleuræ, and the phrenic vessels and nerves; *behind*, the descending aorta, the bronchi, the gullet, the thoracic duct, the vagus nerves, and the vena azygos major. An irregular area on the front of the heart at the lower third of the gladiolus and extending about two inches to the left of it is not covered by the lungs during expiration; during inspiration this space is much diminished.

THE PHYSIOLOGICAL ANATOMY OF THE BLOOD-VESSELS.

Before one studies the systematic anatomy of the blood-vessels, it is important that he should know their physiological anatomy. The few succeeding pages, therefore, will be devoted to a presentation of the principal features of the structure of the different kinds of vessels, with especial reference to the relations between their histological composition and their functions.

The Arteries.

The arteries (*arteriæ*) are the tubes by which blood is carried away from the heart. The name etymologically conveys the idea that these vessels are air-bearers, the ancients regarding them as performing the function of distributing air to the tissues, because they contain no blood or other liquid after death. But although this belief was long ago exploded, the name is not altogether inappropriate, and may be considered a prophetic blunder; for physiology demonstrates that the blood in the arteries is laden with oxygen, which is the essential nourishing ingredient in the air, and the most important element in the income of the body.

The Coats of Arteries.—An artery has three coats—an inner, a middle, and an outer. The points of especial practical value about these tunics are as follows: the *inner coat* (tunica intima) is serous, like the lining of every other portion of the vascular system; the *outer coat* (tunica adventitia) is composed of white fibrous tissue, with its bundles arranged longitudinally; and between these two is the *middle coat* (tunica media), made up of plain muscular and yellow fibrous tissues (Fig. 455).

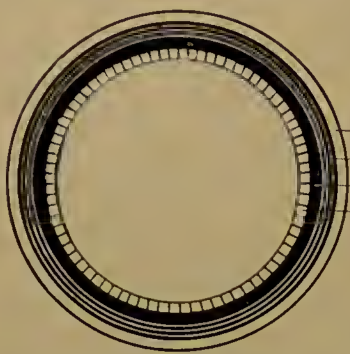


Fig. 455.—Diagram of a cross-section of an artery, showing the composition of its tunics. (F. H. G.)

While this statement of the structure of the arteries embraces the essential features of their physiological anatomy, a somewhat detailed description will not be out of place. The inner coat has three layers: an epithelial, consisting of flat, polygonal cells; a sub-epithelial, of white fibrous tissue, with sometimes yellow fibrous; and an elastic, of yellow fibrous tissue, closely reticulated. The middle coat is composed of plain muscular fibres, arranged crosswise in layers (Fig. 456), between which there is more or less yellow fibrous tissue. The outer coat, mostly of white fibrous, contains yellow fibres. Thus it appears that each tunic has some elastic tissue, the bulk of which, however, is an ingredient of the middle one.

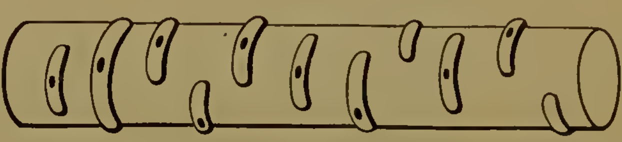


Fig. 456.—Diagram of the arrangement of muscle-cells in an arteriole. (F. H. G.)

The Functions of the Arterial Coats.—The inner tunic by its smoothness reduces the friction of the blood-current to its lowest terms; the outer by its strength and toughness is protective; the middle by virtue of its elasticity enables the vessel to return passively to its average diameter after it has been distended, and on account of its contractility serves actively to reduce the bore of the tube to less than its average. The larger the artery the greater is the relative amount of yellow fibrous tissue; and the smaller the artery the greater the relative amount of muscular tissue. The relativity of the quantity of these ingredients should be carefully noted; for, while the comparative contribution of muscle to a minute artery is great, its absolute amount is very small. From these facts it may be inferred that the large arteries are very elastic and but slightly contractile; the small are highly contractile, and only feebly elastic; and those of medium size possess both of these attributes to a considerable extent, the one or the other predominating according to the degree of nearness to the distal or the proximal limits of the arterial system.

Vessels and Nerves of Arteries.—Outside of the artery is an enclosing *sheath* of areolar tissue, in which are situated the nerves and blood-vessels of the artery itself. These are called respectively *nervi arteriarum* and *vasa arteriarum*; but, as the veins are similarly provided, generic, instead of the above specific, names are more frequently used—*nervi vasorum* and *vasa vasorum*, respectively "the nerves of the vessels" and "the vessels of the vessels." In surgical operations

it is important to avoid unnecessary separation of the sheath from the artery, because the destruction of the feeding vessels of the latter deprives the part of its nourishment, and results in its death. The vasa vasorum are either branches of the artery which they supply, being given off a little distance above their areas of distribution, or else they are contributed by a neighboring artery.

The Branching of Arteries.—The arterial system is aptly compared to a tree, from whose trunk many large branches spring, each of these giving origin to smaller branches, and so on until the most diminutive twigs are reached. Various methods of branching are observed in arteries (Fig. 457). Often an artery

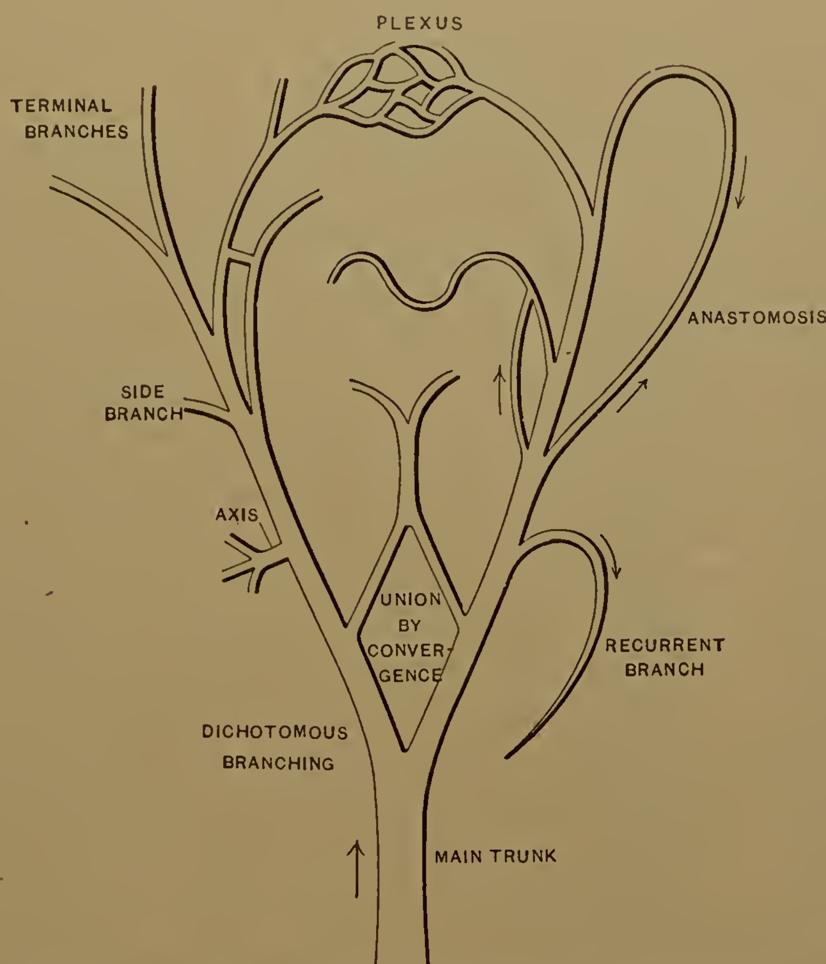


FIG. 457.—Diagram showing the branchings, anastomoses, and confluence of arteries. (F. H. G.)

divides into two terminal branches of nearly equal size, this method being called dichotomous, because the end of the vessel is split in two. Rarely an artery terminates in three approximately equal branches that diverge from the parent stem, which hence is called an *axis*. Most branches spring from the sides of an artery, and are, consequently, said to be given off in its course. These lateral branches usually form acute angles with their trunk, but sometimes right angles, and occasionally obtuse.

The *sectional area of an artery* is always less beyond the point at which a branch springs from it; but the combined sectional area of the immediate branches of an artery is always greater than that of the trunk from which they originate. Consequently, the capacity of the arterial system at any given distance from the heart exceeds that at any plane proximal to this, and thus there is vastly more blood in the smallest arteries (arterioles) than in the aorta and pulmonary artery, which receive the fluid directly from the heart.

Arteries generally pursue a course which is substantially straight or describes a generous curve; but some are serpentine, presenting a tortuous appearance, and this condition obtains in localities where the parts are liable to great changes of form, in some of which the vessel, if straight during quiescence, would be subjected to destructive stretching.

The *course of the blood* in the arteries is, as a rule, from centre to periphery; but exceptions occur, as in the case of the so-called recurrent arteries, which run backward, carrying the blood toward the heart. These vessels are frequent about

movable joints, and insure a plentiful supply of blood, when extreme flexion interferes with the direct and usual provision.

When the distal end of one artery is united to the end of another, so that the blood can flow in either direction, the arrangement constitutes an *anastomosis*, because the tubes are "mouth to mouth," and is also called an *inosculation*, which means "a kissing by mouths." Frequently a number of arteries form many and free inosculations within a limited area, thus making a network or *plexus*. Two arteries of equal size may unite, not by anastomosis, but to form a trunk, just as two venous radicles combine to constitute a larger vein. The vertebrals thus constitute the basilar artery.

The Capillaries.

At the periphery of the arterial system the vessels are microscopic, and consist of hardly more than the epithelium of the intima and a few scattered muscle-cells. When this imperfect contractile covering disappears, the vessel ceases to be an artery and becomes a capillary. The name *capillary* means hair-like; but these vessels are much finer than hairs, some of them having so narrow a lumen that a colored corpuscle of the blood cannot pass through it without being squeezed out of its normal shape. The length of a capillary is only a minute fraction of an inch. The wall of the tube is epithelial (Fig. 458), and is so thin that the materials of the blood pass through it into the spaces around the tissues, and the waste substances of the tissues traverse it in the opposite direction, and enter the blood. The capillaries are arranged in networks. The fineness of the vessels and the size and shape of the areas between them vary greatly. Thus, in the muscles the capillaries run between the fibres, and for the most part have a direction parallel with the fibres, the longitudinal being connected by obliquely crossing vessels, and enclosing long, narrow spaces, bounded by nearly straight lines; but in the air-vesicles of the lungs the capillaries are tortuous, very large, irregular, and so closely placed that the distance between them in some places is less than their own diameter. Some capillary vessels come from veins instead of arteries. For example, the interlobular branches of the portal vein give off the capillary plexus within the lobule, and from this the blood is collected by the intralobular vein.

FIG. 458.—Capillaries, showing the shape and arrangement of the cells which make their wall. (Carpenter.)

The Veins.

The *veins* are vessels which conduct the blood from the periphery toward the centre of the vascular system. They begin where the capillaries end. As the loss of the last semblance of a middle coat changes an arteriole into a capillary, so the addition of a tunic, however scanty, to a capillary converts it into a *venule* ("little vein"). The venous system is comparable to the portion of a tree which is in the ground. It begins in rootlets at the distal end of the capillaries (Fig. 459). These minute veins are properly called *radicles* or *tributaries*, and the same terms are used to designate veins of any size, which by their confluence form a larger vessel. They are often called branches instead of radicles; but the term "branches" should be restricted to vessels resulting from division rather than from union. The desirability of the distinction is perceived in cases where a vein divides into two or more veins. The last are clearly branches of a parent stem, but, at the same time, are radicles of one or more veins nearer the heart.

The veins are more numerous than the arteries, and the capacity of the venous system is considerably greater than that of the arterial.

The veins have a structure, which in the main, is like that of the arteries; but there are such variations of detail that, in some respects, the two sets of vessels behave very differently. The *inner coat* is essentially like the arterial intima, with the addition of numerous transverse folds, which, strengthened by plates of white fibrous tissue, form *valves* (Fig. 460). The *middle tunic* is thinner than that of the arteries of comparable size, contains less muscle, more white fibrous, and only a little yellow fibrous tissue. The *external coat* is very like that of the arteries. This combination results in vessels which are very strong, capable of sustaining more strain than arteries without giving way, but so flabby that they collapse when emptied of blood; whereas arteries, stiffened as they are with elastic and a large amount of muscular tissue, stand open in similar circumstances.

Fig. 459.—Diagram, showing the formation of large veins by convergence of small, and the branching of veins. (F. H. G.)

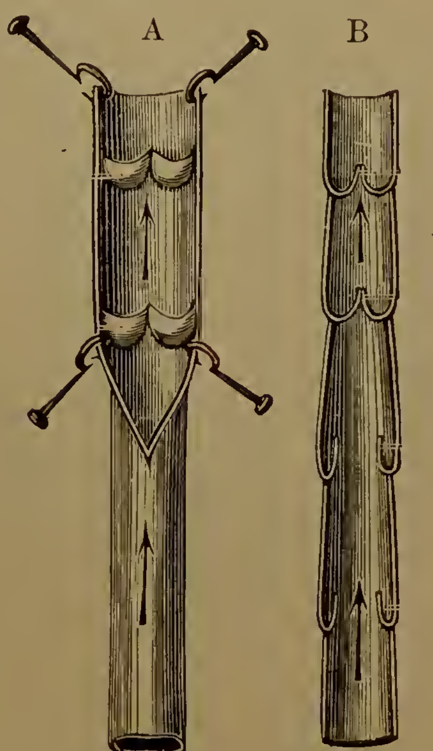


Fig. 460.—Valves of veins. A shows a vein cut open between the segments of two valves. B shows appearance of valves closed and open. (Testut.)

The *valves* are not found in all veins. They generally have two flaps each, which are directed toward the heart, when open. At the base of each valve the vein bulges, forming a *sinus*, into which the blood enters as soon as any obstruction to its flow occurs, and causes instant closure of the valve.

A few *exceptions* are found to the rule that capillaries intervene between arterioles and venules. In the interior of erectile organs small arteries may open directly into venous cavities; and in the spleen the arteries discharge into the interstices of the organ.

THE ARTERIES.

By A. D. BEVAN.

THE arteries are divided into two sets. One of these carries the vitiated blood from the right ventricle of the heart to the lungs, in which it gets rid of certain impurities and gains oxygen. This is the *pulmonary* ("lung") set. The other conveys nourishing blood from the left ventricle of the heart to the tissues throughout the body, and is called the *systemic* set.

The branches of the systemic arteries, as a rule, supply the structures among which they course; and, since this fact may be safely assumed, it is not always stated in the text. It may also be inferred that, where two or more arteries are distributed to the same region, an anastomosis occurs between their small branches.

While studying the arteries of a region, one will derive valuable assistance from a consultation of the figures of other structures in the same locality, particularly those in the chapters on the veins and the nerves. By pursuing this plan the relations of the parts will be much more readily comprehended.

THE PULMONARY ARTERY.

The **Pulmonary Artery** (Fig. 461) carries the venous blood from the right ventricle to the lungs. It arises from the upper and front part of the right ventricle, and passes upward, backward, and to the left for the distance of two inches, the vessel being contained in the pericardial cavity. Its termination is at a point beneath the transverse portion of the aorta opposite the fifth thoracic vertebra. Here it divides into the right and left pulmonary arteries.

Relations.—*In front* is the pericardium, superficial to which are the remains of the thymus, and the left pleura and lung, which respectively are behind the gladiolus and the sternal end of the second intercostal space. *Behind* its lower part is the ascending part of the arch of the aorta; higher up is the left auricle. *At the right* are the ascending part of the aortic arch, the right auricular appendix, and the right coronary artery. *At the left* are the pericardium, the left pleura, the left auricular appendix, and the left coronary artery.

The *right pulmonary artery* passes beneath the aortic arch to the right lung, and breaks up into three branches supplying the upper, the middle, and the lower lobes.

The *left pulmonary artery* passes in front of the descending aorta to the root of the left lung, and divides into two branches supplying the upper and lower lobes.

The pulmonary arteries carry venous blood to the lobules of the lungs, in which it experiences the changes produced by the function of respiration, the structure of the lungs being supplied with arterial blood by the bronchial arteries, branches of the thoracic aorta. The branches of the pulmonary arteries do not anastomose with each other—they are terminal arteries.

Passing from the pulmonary artery to the arch of the aorta is a fibrous cord, the remains of the *ductus arteriosus*, a vessel, which in the fœtal circulation

carries the blood sent through the pulmonary artery into the aorta. After birth this soon disappears; but, as an abnormality, it may persist.

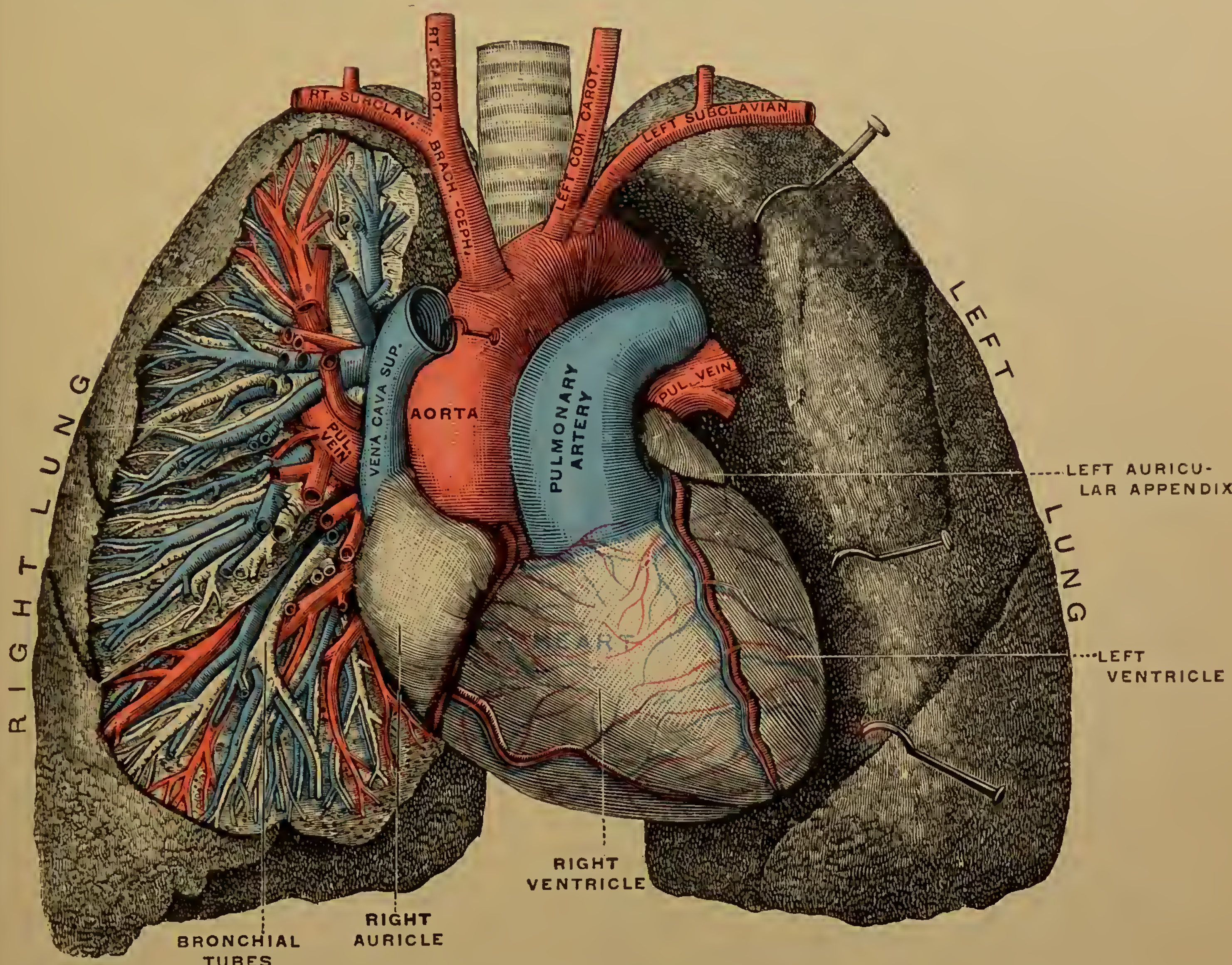


FIG. 461.—The pulmonary artery and aorta. The front part of the right lung has been removed, and the pulmonary vessels and the bronchial tubes are thus exposed. (Testut.)

THE SYSTEMIC ARTERIES.

The arteries of the systemic circulation all come directly or indirectly from the aorta. This great trunk will first be described, and afterward in regular sequence its branches will be traced to their ultimate destination. In this plan an orderly method will be pursued, and the origin, course, branches, distribution, and relations of each artery will be presented. Where important anastomoses occur, and variations from what is believed to be the normal are frequently observed, these facts will be noted.

THE AORTA.

General Description.—On leaving the left ventricle of the heart the aorta forms an arch, which extends backward to the vertebral column. Then the vessel runs downward on the bodies of the vertebræ to its termination at the fourth lumbar vertebra. In the artery itself there are no lines of demarcation separating it into distinct parts; but conventional divisions have been made for ease of description. The arch reaches to the lower border of the fifth thoracic vertebra; from this point to the aortic opening in the diaphragm the vessel is called the thoracic aorta; and all below that is known as the abdominal aorta. From each of these portions branches are given off. At its very beginning the aorta sends the coronary arteries to the heart. From the top of the arch spring three great vessels, which supply the head, the neck, the upper limbs, and a part of the thorax. From the thoracic aorta originate arteries which are distributed to the greater part of the parietes of the chest, and to all of its viscera, except-

ing the heart. The abdominal aorta supplies the diaphragm and the larger part of the walls of the belly, the viscera of the abdomen proper, and a part of those in the pelvis, and finally divides into two great vessels, which carry blood to the pelvic walls and viscera, to a part of the abdominal parietes, to the external genitals, and to the lower limbs.

The aorta is divided by some anatomists into an ascending aorta, an arch, and a descending aorta, the ascending aorta corresponding to the ascending portion of the arch in the description which is given here, the arch corresponding to the transverse portion of the arch, and the descending aorta beginning at the lower border of the fourth thoracic vertebra, and, therefore, including the descending portion of the arch in the division here adopted.

THE ARCH OF THE AORTA.

The arch (Fig. 461) is divided into three portions: the ascending, the transverse, and the descending.

The Ascending Portion of the Arch.

The *ascending portion,* two inches long, begins at the postero-superior part of the left ventricle, opposite the lower border of the left third costal cartilage, and behind the sternum. It passes upward and to the right to the level of the upper border of the second costal cartilage. At its origin it is enlarged and presents three bulges, the *sinuses of Valsalva,* each guarded by a semilunar flap of the aortic valve.

Fig. 462.—Horizontal section through the sixth thoracic vertebra—upper surface of the lower segment—showing the ascending portion of the aortic arch, and the thoracic aorta. (Braune.)

Relations (Fig. 462).—*In front* are the right auricular appendix and the pulmonary artery, below; the pericardium, the right pleura and lung, and the remains of the thymus gland, above. *Behind* are the left auricle, below; the right pulmonary artery, and the right bronchus, above. *At the right* are the right auricle, below, and the superior vena cava, above. *At the left* is the pulmonary artery.

The Transverse Portion of the Arch.

The *transverse portion* (Fig. 463), nearly two inches long, begins on a level with the upper border of the left second costal cartilage, curves with an upward convexity backward and to the left, and ends at the lower border of the fourth thoracic vertebra at its left side.

Relations.—*In front* are the left phrenic nerve, cardiac nerves from the vagus and sympathetic, the left vagus, the left superior intercostal vein, and vestiges of the thymus, all overlapped by the front borders of the pluræ and lungs. *Behind* are the trachea, the left recurrent laryngeal nerve, and the deep cardiac plexus,—the gullet and the thoracic duct being on a plane behind. *Above* are the left brachio-cephalic vein, and the beginning of the three great vessels which spring from the arch. *Below* are the bifurcation of the pulmonary artery, the left bronchus, the ductus arteriosus, bronchial lymph-nodes, the left recurrent laryngeal nerve, and the superficial cardiac plexus.

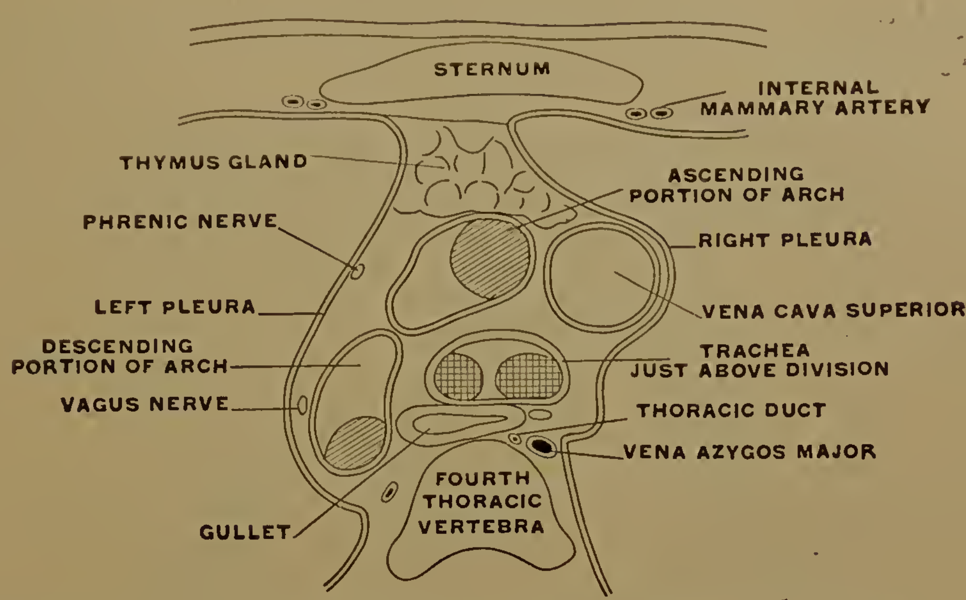


FIG. 463.—Horizontal section through the fourth thoracic vertebra—upper surface of the lower segment. The cut is made at the lower part of the transverse portion of the aortic arch. (Braune.)

THE DESCENDING PORTION OF THE ARCH.

The *descending portion* runs downward on the ventro-sinistral aspect of the body of the fifth thoracic vertebra and the cartilaginous disc above it. It has a markedly smaller diameter than the first portion on account of the great size of the vessels given off by the transverse portion.

Relations.—*In front* are the left pleura and the root of the left lung. *Behind* and at the right are the body of the fifth thoracic vertebra and the intervertebral disc above it. *At the right* are the gullet and the thoracic duct. *At the left* are the left pleura and lung.

THE THORACIC AORTA.

The *thoracic aorta* (Fig. 504) is situated in the posterior mediastinum. It begins at the lower border of the fifth thoracic vertebra on its left side and toward the front, and passes downward and mesially to the lower border of the twelfth thoracic vertebra in the middle line, conforming in its course to the curve of the part of the spinal column to which it is so closely applied.

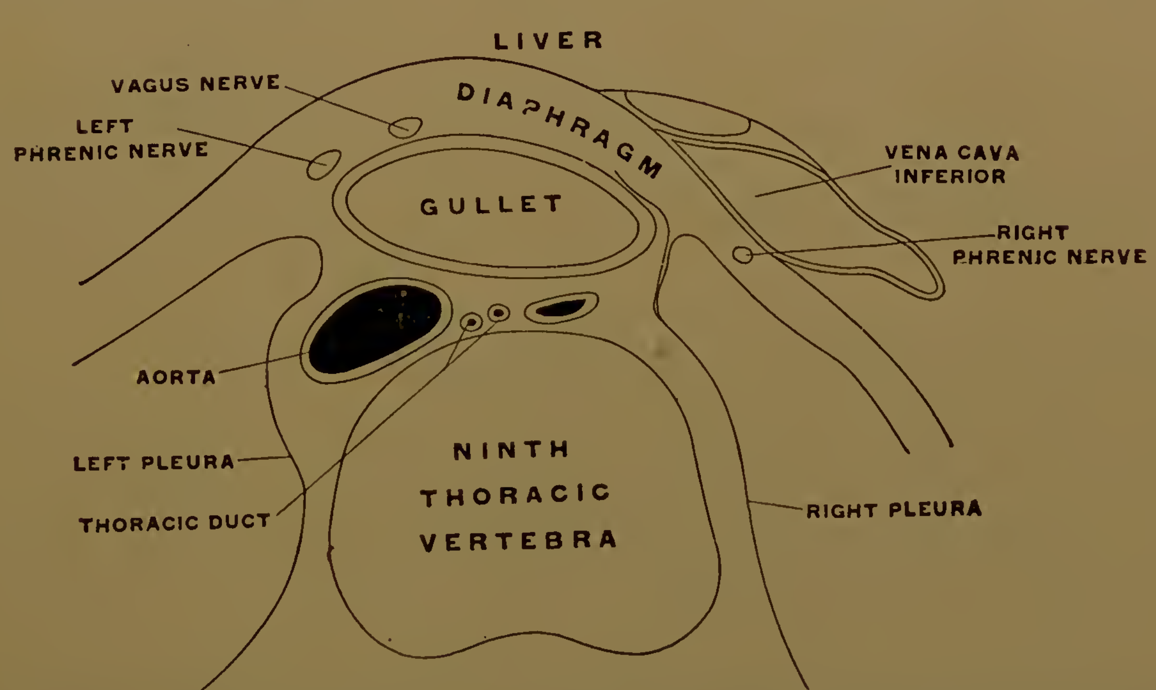


FIG. 464.—Horizontal section through the ninth thoracic vertebra—upper surface of the lower segment. (Braune.)

Relations (Figs. 462, 464, 465).—*In front* are the root of the left lung, the gullet, which crosses the artery from right to left, the pericardium, and, below, the diaphragm. *Behind* are the thoracic vertebræ and their intervertebral discs from the sixth to the twelfth, and the vena azygos minor. *At the right* are the

gullet, above, the thoracic duct, the vena azygos major, and the right pleura and lung. *At the left* are the left pleura and lung, and, below, the gullet.

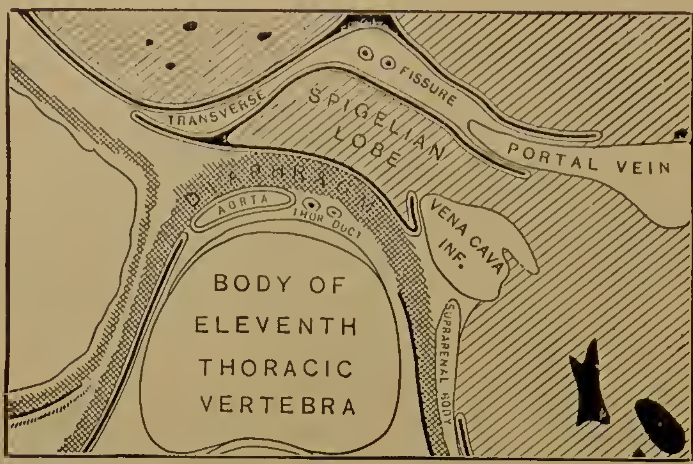


FIG. 465.—Horizontal section through the eleventh thoracic vertebra—upper surface of the lower segment. (Braune.)

THE ABDOMINAL AORTA.

The **abdominal aorta** (Fig. 505) begins at the lower border of the twelfth thoracic vertebra in the middle line, passes downward and slightly to the left, and ends on the ventro-lateral surface of the body of the fourth lumbar vertebra, bifurcating into the common iliac arteries.

Relations (Figs. 466, 467).—*In front* are the solar plexus, the splenic vein, the pancreas, the left renal vein, the third portion of the duodenum, the aortic plexus, in order from above downward; small intestines, and the median lumbar lymph-nodes. *Behind* are the upper four lumbar vertebræ and their fibro-cartilages, the left crus of the diaphragm, and the left lumbar veins. *At the right* are the right crus, the vena cava inferior, the receptaculum and the thoracic duct, the right semilunar ganglion, and the vena azygos major. *At the left* are the left crus, the left semilunar ganglion, the pancreas, and small intestines.

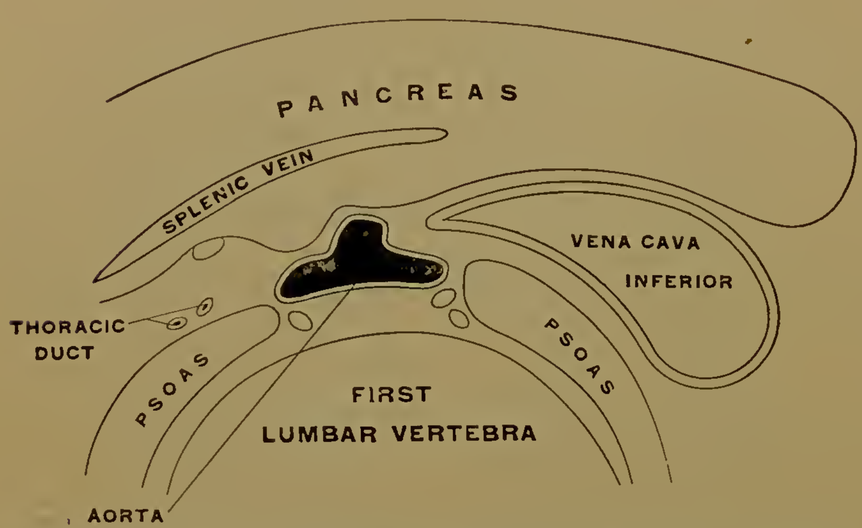


FIG. 466.—Horizontal section through the first lumbar vertebra—upper surface of the lower segment. (Braune.)

Variations.—The arch of the aorta varies as regards the height to which it rises, the direction in which it runs, and its conformation. There are also many cases of deviation from the normal in the number, position, and arrangement of the branches from the transverse position. It is unnecessary, however, from the practical point of view to specify these variations in detail. The ductus arteriosus may persist as a vessel. The thoracic and abdominal portions of the aorta are much less subject to variations than is the arch. The thoracic is sometimes obliterated just below the arch, in which case the blood reaches the parts below by means of a collateral circulation through branches of the great vessels of the arch, which anastomose with recurrent branches from the abdominal aorta. The last named may bifurcate a little lower than usual, or a great deal higher, possibly at the level of the second lumbar vertebra.

Branches.—The vessels which arise from the aorta will be considered in the order of their origin.

The **branches of the arch** are the right coronary and the left coronary arteries, which are given off from the ascending portion, and the brachio-cephalic, the left

common carotid, and the left subclavian arteries, which arise from the transverse portion.

The **Right Coronary Artery** (Fig. 452) arises from the anterior sinus of Valsalva, winds to the right in the auriculo-ventricular groove to the posterior interventricular groove, where it divides into two branches, one of which continues in the auriculo-ventricular groove, while the other descends in the interventricular.

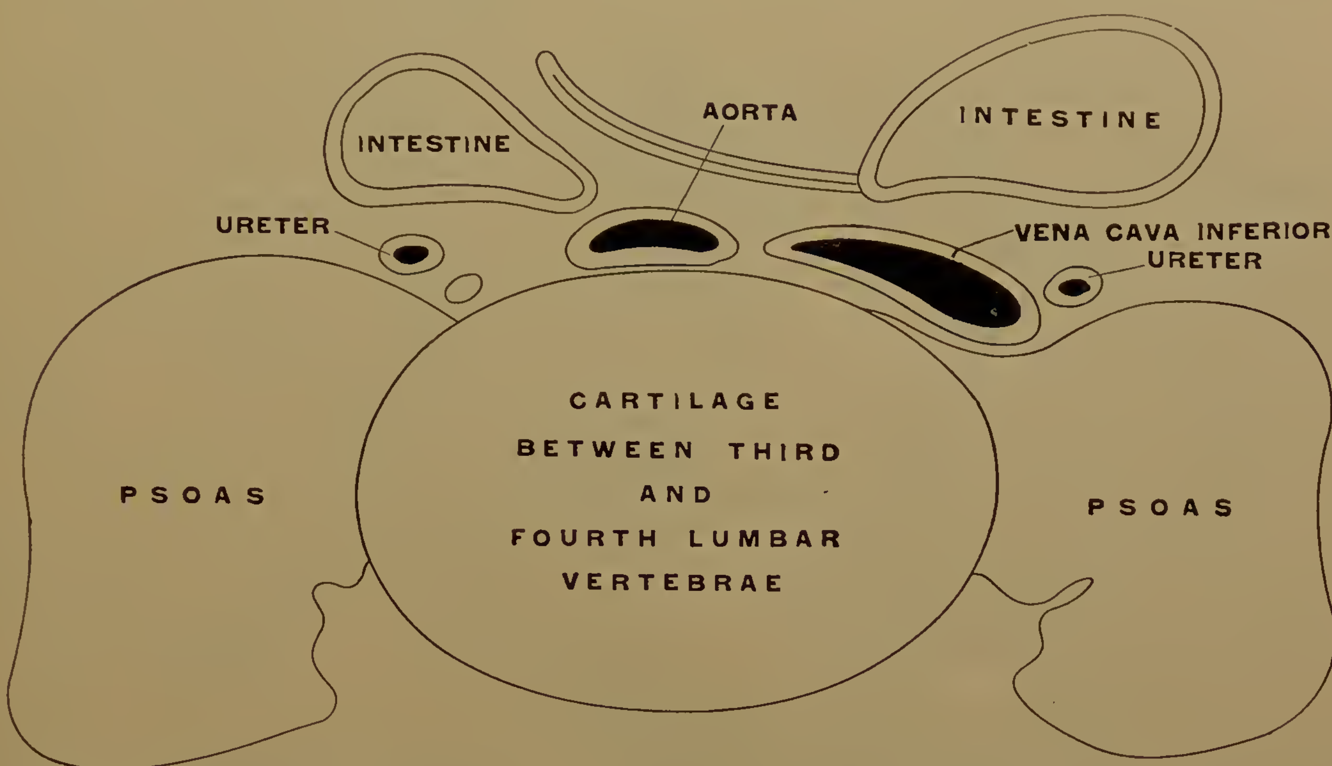


FIG. 467.—Horizontal section between the third and fourth lumbar vertebræ—upper surface of the lower segment. (Braune.)

The **Left Coronary Artery** (Fig. 452) springs from the left posterior sinus of Valsalva, runs forward behind the pulmonary artery and bifurcates,—one branch descending in the anterior interventricular groove to the apex, the other running backward in the auriculo-ventricular groove, and anastomosing with the right coronary.

The coronary arteries supply the heart and the contiguous portions of the aorta and pulmonary artery. They are called "coronary," because they encircle the heart like a crown ("corona").

The brachio-cephalic, the left common carotid, and the left subclavian arteries arise from the top of the arch in the order given; and as the arch extends backward and to the left, the brachio-cephalic is nearest the front, the left subclavian farthest from the front, and the left common carotid between the two, and somewhat nearer the brachio-cephalic.

THE BRACHIO-CEPHALIC ARTERY.

The *brachio-cephalic* ("arm-head") *artery* (Fig. 461), often called *innominate*, as if it had no name, is from an inch and a half to two inches long. It springs from the arch of the aorta opposite the upper border of the second costal cartilage on the right side, passes upward and to the right in front of the trachea, and ends behind the top of the sterno-clavicular joint, there dividing into the right common carotid and right subclavian arteries.

Relations (Fig. 468).—*In front* of its lower part are the left brachio-cephalic and right inferior thyroid veins, and higher up the sterno-hyoid and sterno-thyroid muscles, and cardiac nerves from the right vagus. *Behind* its lower part is the trachea, behind its upper part the right pleura and lung. *At the right* are the right brachio-cephalic vein, the right vagus nerve, and the right pleura and lung. *At the left* are the left common carotid artery, the left inferior thyroid vein, and the trachea.

Variations.—The brachio-cephalic may be absent, the right common carotid and subclavian springing directly from the aorta. It may be longer or shorter than usual—less than an inch, or more than two inches in length.

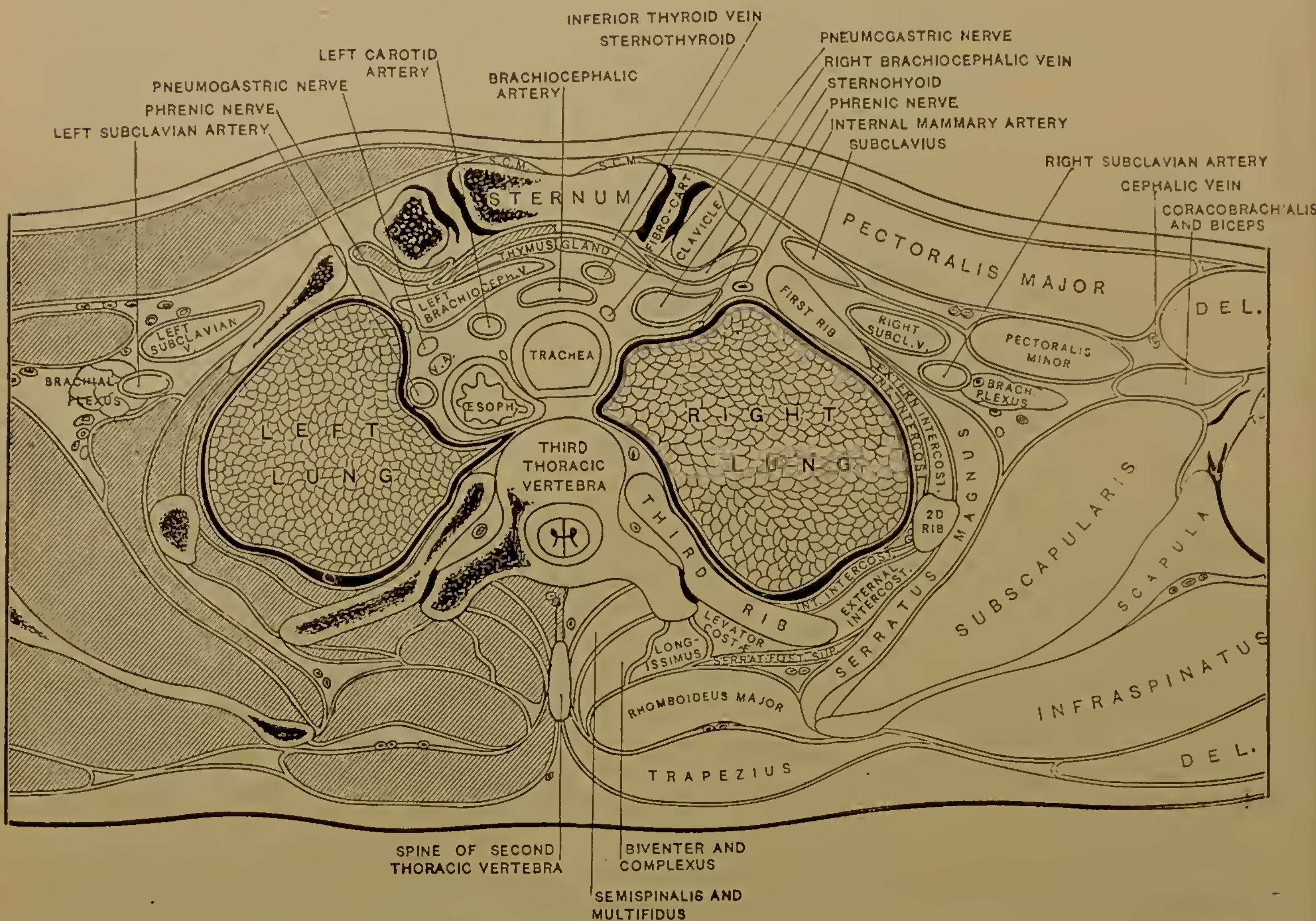


FIG. 468.—Horizontal section through the third thoracic vertebra—upper surface of the lower segment—showing the relations of the brachio-cephalic artery. (Braune.)

Branches.—In addition to the terminal branches, the right common carotid and right subclavian, the brachio-cephalic occasionally gives off a branch, the *thyroidea ima*, which passes upward on the surface of the trachea to the isthmus of the thyroid.

THE COMMON CAROTID ARTERY.

The name "carotid" is derived from a Greek word, signifying "to produce sleep," and was applied to certain arteries because they were supposed to be concerned in the causation of sleep.

The *common carotid arteries* (Fig. 470) differ upon the two sides. The right takes its origin from the brachio-cephalic, the left from the arch of the aorta; the left is, therefore, the longer of the two. In the neck the common carotids are so nearly alike that one description will answer for both. It will be necessary, however, to describe that portion of the left carotid which extends from the arch to the level of the sterno-clavicular articulation.

The Left Carotid Artery in the Thorax.

This portion resembles somewhat the brachio-cephalic artery in length and in its relation to surrounding structures. Arising from the arch of the aorta close to the brachio-cephalic, it passes upward and sinistrally behind the manubrium and the anterior margin of the left lung to the level of the left sterno-clavicular joint.

Relations.—*In front* are the remains of the thymus gland, and the left brachio-cephalic vein—the latter low down. *Behind* are the trachea, gullet, thoracic duct,

and left recurrent laryngeal nerve. *At the right* are the brachio-cephalic artery below, and the trachea and left inferior thyroid vein above. *At the left* are the left lung with its pleura, and the left subclavian artery and left vagus nerve—the last two being somewhat at the rear.

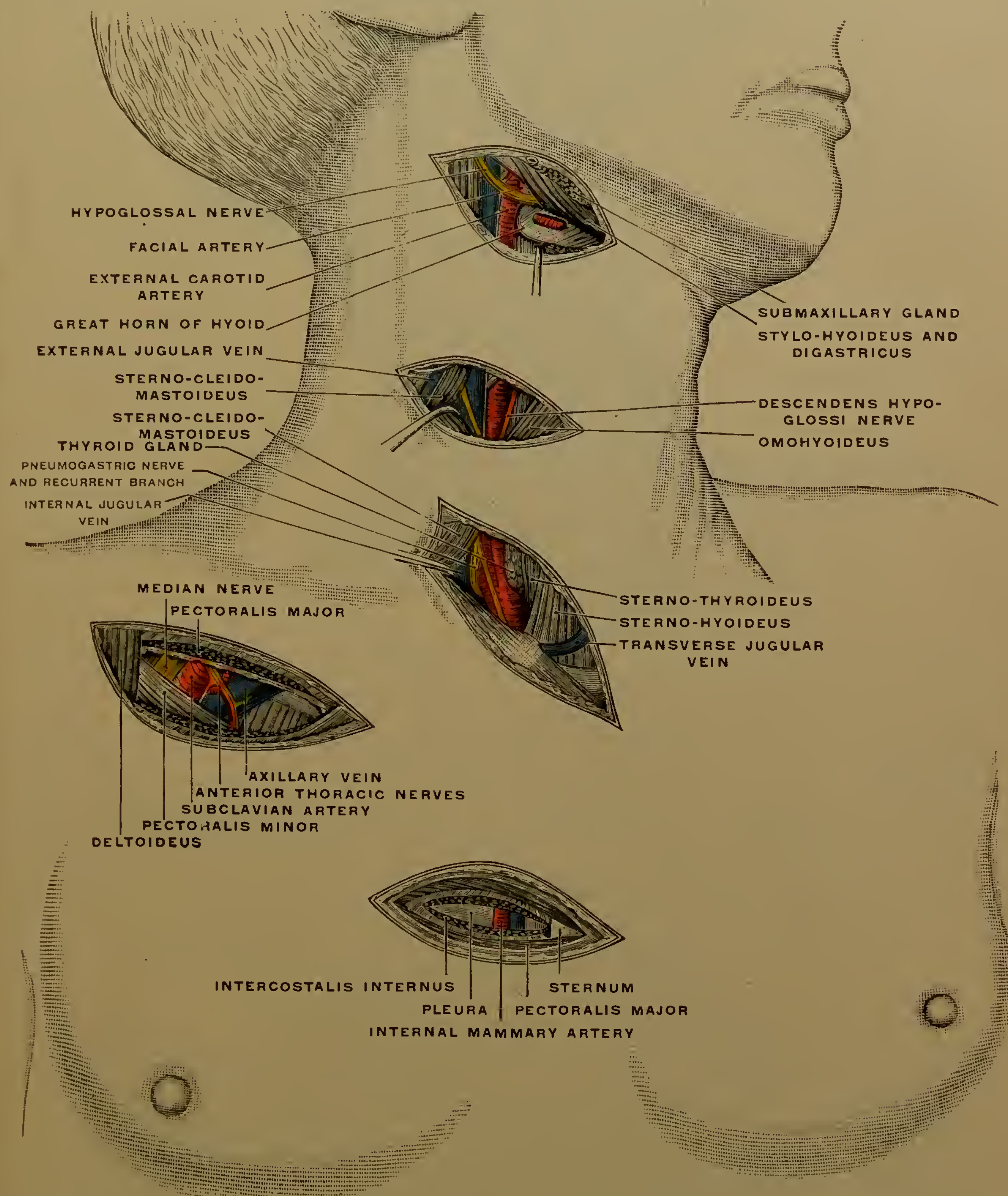


FIG. 469.—Surgical relations of the lingual, external carotid, common carotid, brachio-cephalic, subclavian, and internal mammary arteries. (Kocher.)

The Common Carotid Artery in the Neck.

The common carotid in the neck begins behind the sterno-clavicular articulation, passes upward and outward in a direction indicated by a line drawn from its origin to a point midway between the angle of the jaw and the mastoid process, and ends at the level of the upper border of the thyroid cartilage by bifurcating into the external and internal carotids. It is overlapped by the sterno-cleido-mastoid muscle, the inner border of which is the guide to its course. It is

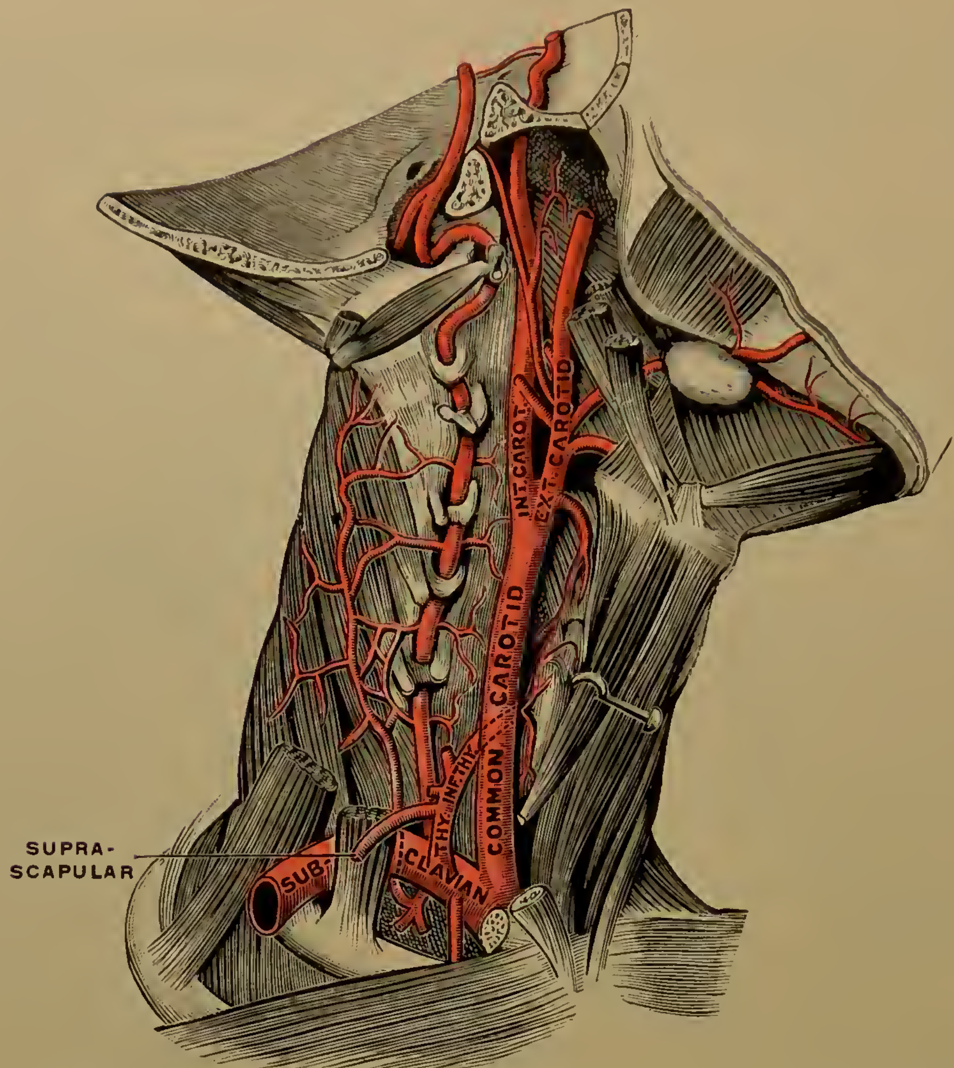


Fig. 470.—Right subclavian and carotid arteries. The vertebral artery is seen threading the costo-transverse processes of the vertebræ. (Testut.)

enclosed in a sheath which is common to it, the internal jugular vein, and the vagus nerve. It is deeply situated at first, but is much nearer the surface in its upper part.

Relations (Fig. 471).—*In front* is the sterno-cleido-mastoid throughout; below are the sterno-hyoid and sterno-thyroid, the thyroid gland, and the anterior

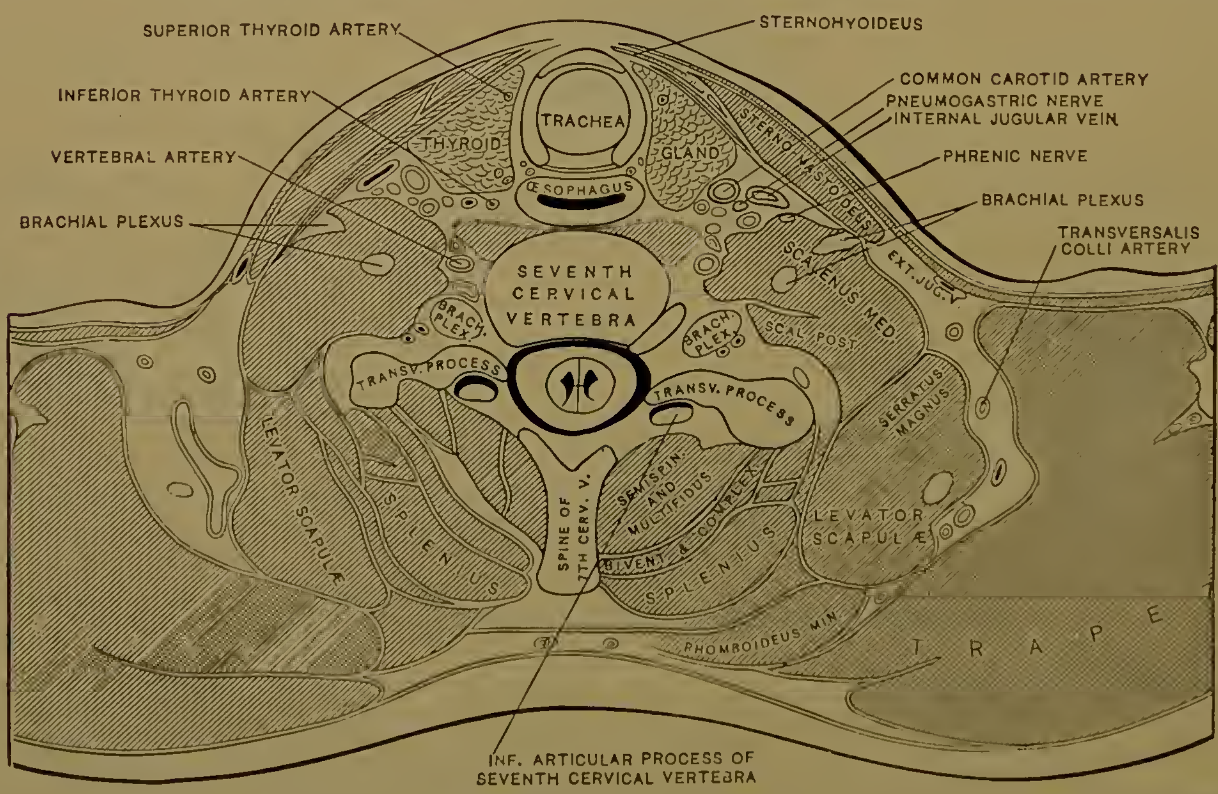


Fig. 471.—Horizontal section through the seventh cervical vertebra—upper surface of the lower segment—showing the relations of the common carotid. (Braune.)

jugular vein; opposite the cricoid cartilage is the omo-hyoid; above are the superior and middle thyroid veins, the sterno-mastoid artery, and the descendens-

hypoglossi nerve—the last either upon or inside of the sheath. *Behind* are the sympathetic nerve; the longus colli, the inferior thyroid artery, and the recurrent laryngeal nerve below; the rectus capitis anterior major above; the vagus nerve is dorso-external to the artery. *On the outer side* is the internal jugular vein, and the vagus nerve behind and between the artery and vein. *On the inner side* are the trachea, thyroid gland, recurrent laryngeal nerve, and inferior thyroid artery below; the larynx and pharynx above.

Variations.—The right common carotid sometimes springs directly from the arch of the aorta; sometimes the left common carotid springs from a left brachio-cephalic artery; the common carotid is sometimes absent, the internal and external carotids springing directly from the arch of the aorta or from a brachio-cephalic artery. In some cases it divides above or below the usual point, low down in the neck, or as high as or higher than the hyoid bone.

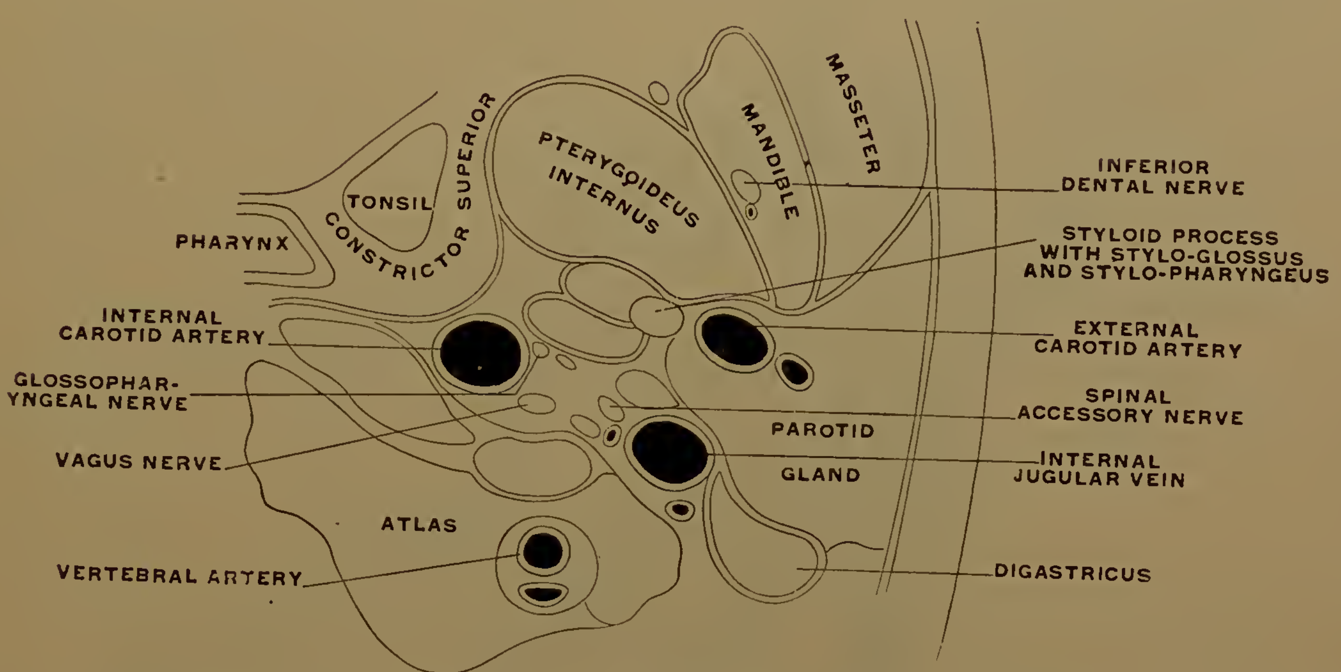


FIG. 472.—Section of the head from the mouth backward and a little upward—upper surface of the lower segment. The internal and external carotids of the right side are shown. (Braune.)

Branches.—The common carotid, as a rule, does not give off any branches in its course; in rare cases it gives off a superior or an inferior thyroid or the vertebral artery. The terminal branches are the internal carotid and the external carotid.

The External Carotid Artery.

The **External Carotid** (Figs. 470, 473), a terminal of the common carotid, begins opposite the upper border of the thyroid cartilage, runs upward and a little backward to a point between the neck of the condyle of the mandible and the external auditory meatus, where, in the substance of the parotid gland, it bifurcates into the internal maxillary and temporal arteries. It is overlapped by the inner border of the sterno-cleido-mastoid muscle in a large part of its course.

It supplies the ventral part of the neck, the superficial and deep parts of the face, the scalp, the dura, and the bones between these, the pharynx, and the external and middle ears.

Relations (Fig. 472).—*In front* are the hypoglossal nerve, the lingual and facial veins below, the digastric and stylo-hyoid muscles at a higher level, the parotid gland, facial nerve, and internal pterygoid muscle above. *Behind* are the internal carotid artery at its origin, the superior laryngeal nerve in the lower part, the stylo-glossus, stylo-pharyngeus, and glosso-pharyngeal nerve at a higher level, and the parotid gland above. *At the inner side*, from below upward, are the hyoid, pharynx, and parotid gland, with the styloid process mesially.

Variations.—The external carotid may arise above or below its usual point. Sometimes the artery arises from the aortic arch. Occasionally the external carotid is altogether absent, the common carotid not dividing into the internal and external carotids, but supplying from a common trunk the branches usually arising from these vessels.

Branches.—The external carotid, in addition to its two terminal branches, the internal maxillary and the temporal, gives off three anterior branches, the superior thyroid, the lingual, and the facial; two posterior branches, the occipital and the posterior auricular; and one internal branch, the ascending pharyngeal.

The *Superior Thyroid Artery* (Fig. 470).—This artery is named from its being the upper of the two vessels that supply the thyroid gland. It comes off from the external carotid close to its origin, runs upward and inward, and then downward and forward to the upper part of the thyroid gland.

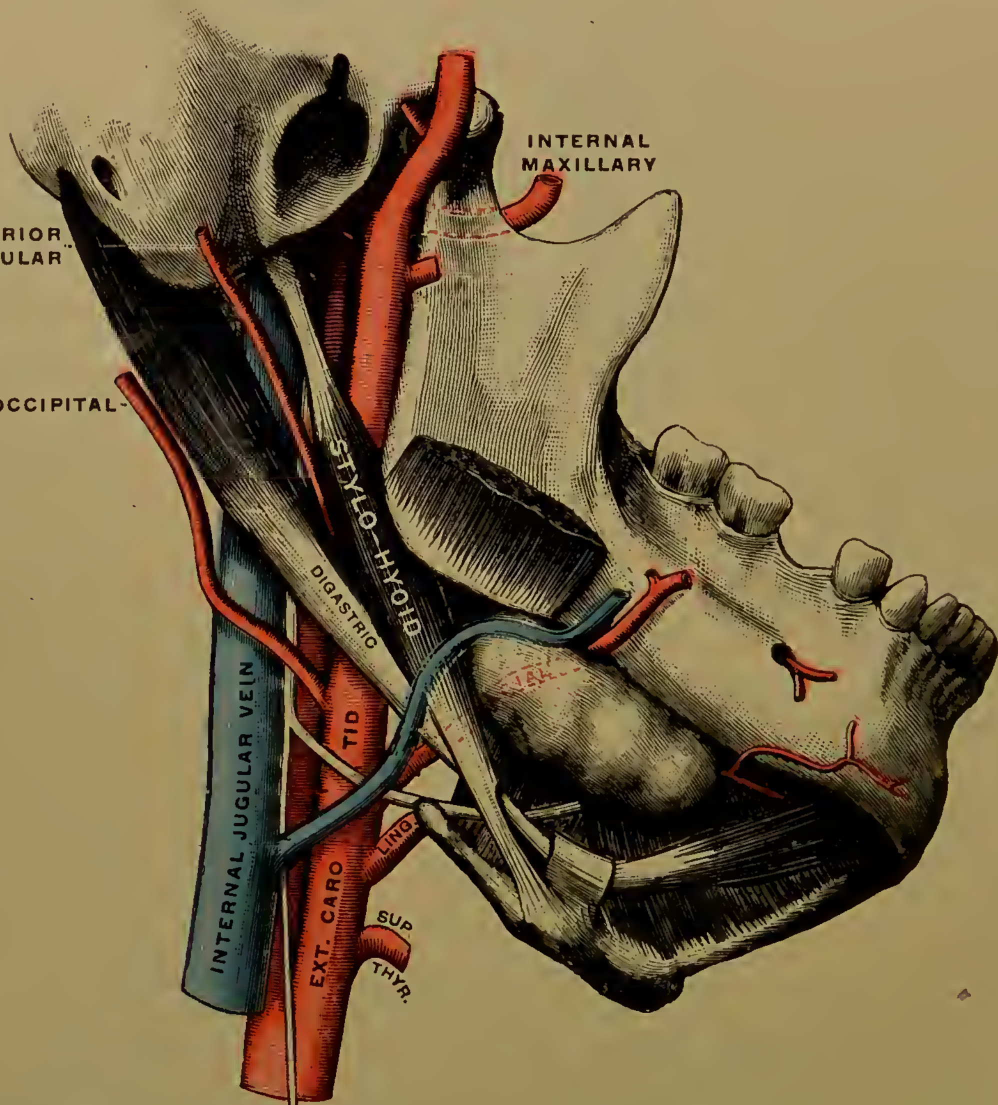


FIG. 473.—The external and internal carotid arteries. The hypoglossal nerve, the digastric and stylohyoid muscles, and the internal jugular vein are to be noted. (Testut.)

Relations.—The superior thyroid at its origin is superficially situated and covered by the skin, superficial fascia, platysma, and deep fascia; before it reaches the thyroid gland it becomes more deeply situated by passing beneath the omohyoid, sterno-hyoid, and sterno-thyroid muscles.

Variations.—The superior thyroid is sometimes given off as a branch of the common carotid, and sometimes as a branch of a trunk from the external carotid, common to it and the lingual or facial.

Branches.—*Muscular* branches are given off to the omo-hyoid, sterno-hyoid, sterno-thyroid, and the inferior constrictor of the pharynx. *Glandular* are supplied to the thyroid gland. The *hyoid* runs along the lower border of the hyoid bone, and gives twigs to the parts just below. The *sterno-mastoid* branch passes outward and downward, and is distributed to the muscle whose name it bears, and

to the platysma and skin. The *superior laryngeal* accompanies the superior laryngeal nerve in its distribution to the interior of the larynx, passing with the nerve through the thyro-hyoid membrane, and supplying the mucous membrane and muscles of the larynx. The *crico-thyroid* artery runs inward on the surface of the crico-thyroid membrane, to the crico-thyroid muscle and the interior of the larynx.

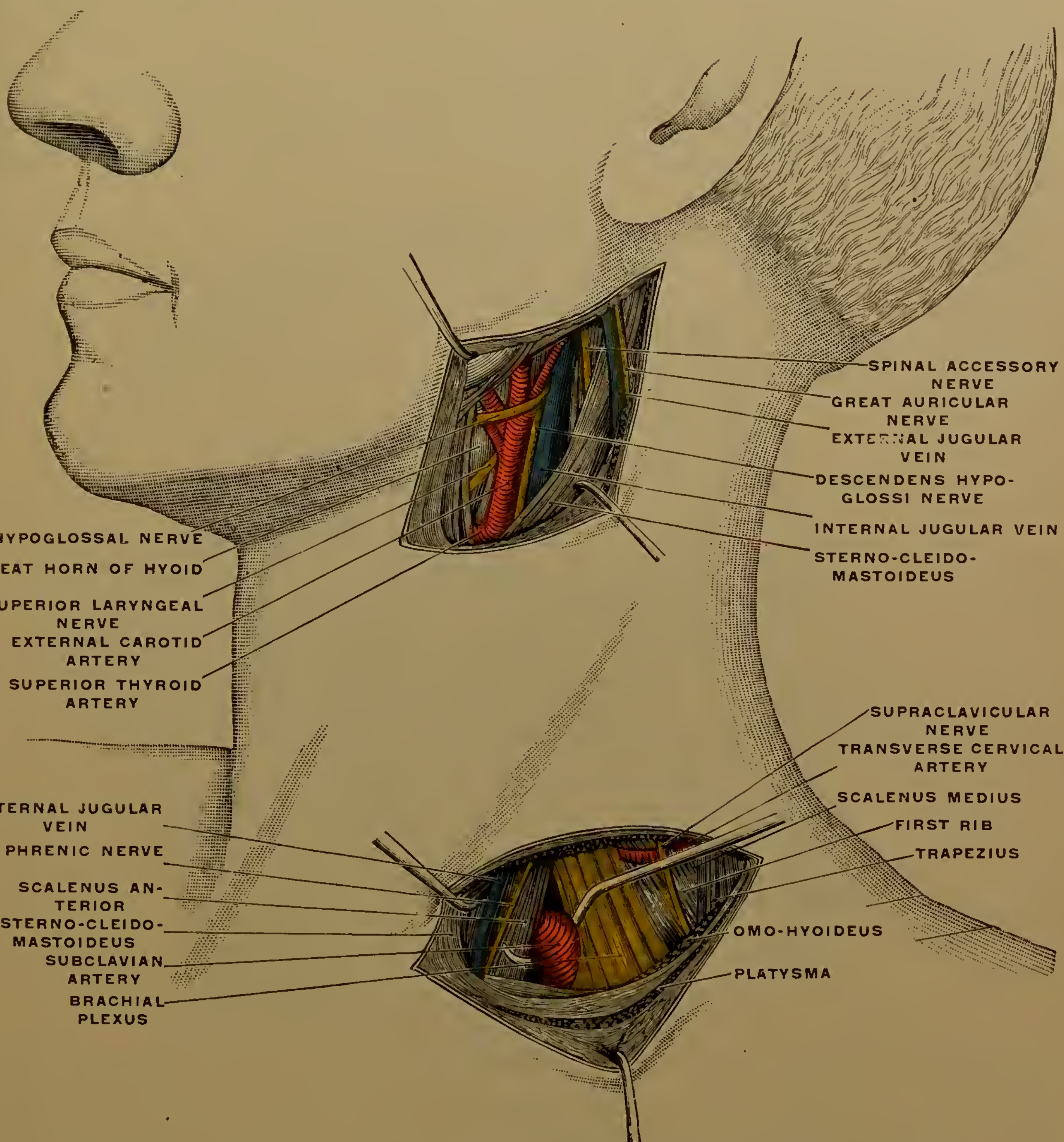


FIG. 474.—Surgical relations of the external carotid, lingual, facial, occipital, subclavian, and transverse cervical arteries. (Kocher.)

The Lingual Artery (Fig. 475).—It springs from the external carotid above the superior thyroid and a little below the hyoid bone, runs along the upper border of the great cornu of the hyoid, then leaves the bone, passes to the base of the tongue, and courses along its under surface, terminating as the ranine artery.

Relations.—The artery is at first superficial, then passes beneath the digastric and hyoglossus muscles, and has in front of it the hypoglossal nerve; later it is situated in the base of the tongue between the hyoglossus and genio-hyoglossus muscles; it then, as the ranine becomes again superficial, being covered only by the mucous membrane of the inferior surface of the tongue.

Variations.—The lingual artery is sometimes a branch from a trunk of the external carotid common to it and the facial, or to it and the superior thyroid; or the three vessels may arise from a common trunk.

Branches of the lingual are the hyoid, dorsal lingual, sublingual, and ranine.

The *hyoid* runs along the upper border of the hyoid bone, and is distributed to adjacent muscles. The *dorsal lingual* runs upward to the mucous membrane of the dorsum of the tongue, which it supplies, together with the tonsil and soft palate. The *sublingual* supplies the sublingual gland, the neighboring muscles, and mucous membrane. The *ranine* gives off branches to the muscles of the tongue, and runs in a tortuous course to its tip, being in the last part of its course superficial, covered only by the mucous membrane.

The Facial Artery (Fig. 476) arises from the anterior surface of the external carotid above the hyoid bone, and passes upward and forward to the inferior border of the lower jaw. In its course it is covered and partly surrounded by the submaxillary gland, so that the vessel occupies a groove on its deep surface. The artery winds over the body of the lower jaw in front of the masseter muscle, marking the bone in this position by a shallow groove. It then passes upward and forward on the face to the side of the nose, and then upward to the inner canthus of the eye, where it terminates as the *angular* artery.

Relations.—At its point of origin the vessel is superficial, being covered by the skin, superficial fascia, platysma, and deep fascia; it then passes beneath the

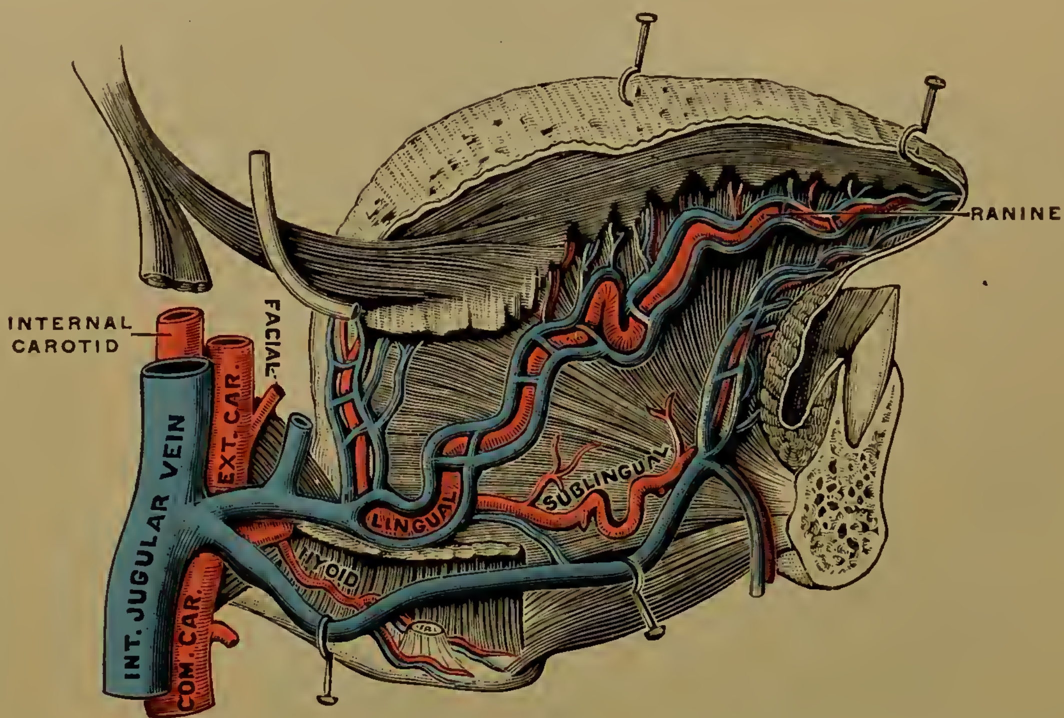


FIG. 475.—Arteries and veins of the tongue, viewed from the right side. (Testut.)

stylo-hyoid and digastric muscles and the submaxillary gland, and is deeply situated. At the border of the jaw the vessel again becomes superficial, and its pulsations can be readily felt in front of the masseter. In the face it passes among the fasciculi of the facial muscles adjacent to it.

Variation.—The variation most commonly met with is the occurrence of a trunk from the external carotid, common to the facial and lingual arteries.

Branches.—The branches of the facial are divided into two sets, a *cervical set* and a *facial set.*

In the cervical region the facial gives off the ascending palatine, the tonsillar, the glandular, the submental, and the muscular. The *ascending palatine* passes to the outer side of the pharynx, which it supplies; it also sends a branch to the soft palate, and anastomoses with the descending palatine artery, a branch of the internal maxillary. The *tonsillar* is a branch to the tonsil and tongue. The *glandular* are branches given off to the submaxillary gland. The *submental* is a large branch which runs along the lower border of the jaw to the chin; here the vessel gives off terminal branches, which wind over the jaw, and supply the tissues of the lower lip. *Muscular* branches are given off to the muscles with which the vessel is in contact. The *facial branches* are the inferior labial, the coronary, the

lateral nasal, the angular, and muscular. The *inferior labial* runs parallel with the body of the jaw forward to the chin; it supplies the tissues of the chin and lower lip. The *coronary* arteries are given off at the angle of the mouth, and run, one in the tissues of the lower lip, the other in the tissues of the upper lip, in close contact with the mucous membrane, sending branches to the ala and septum of the nose. The *lateral nasal* supplies the ala and dorsum of the nose. The *angular* is the terminal branch of the facial. It ascends to the inner canthus of the eye, and supplies the structures in this position, anastomosing with the infra-orbital, and with the nasal branch of the ophthalmic artery.

The Occipital Artery (Fig. 476) arises from the external and posterior surface of the external carotid, opposite the facial, at a point a little above the level of the hyoid bone. It winds upward and backward to the mastoid portion of the

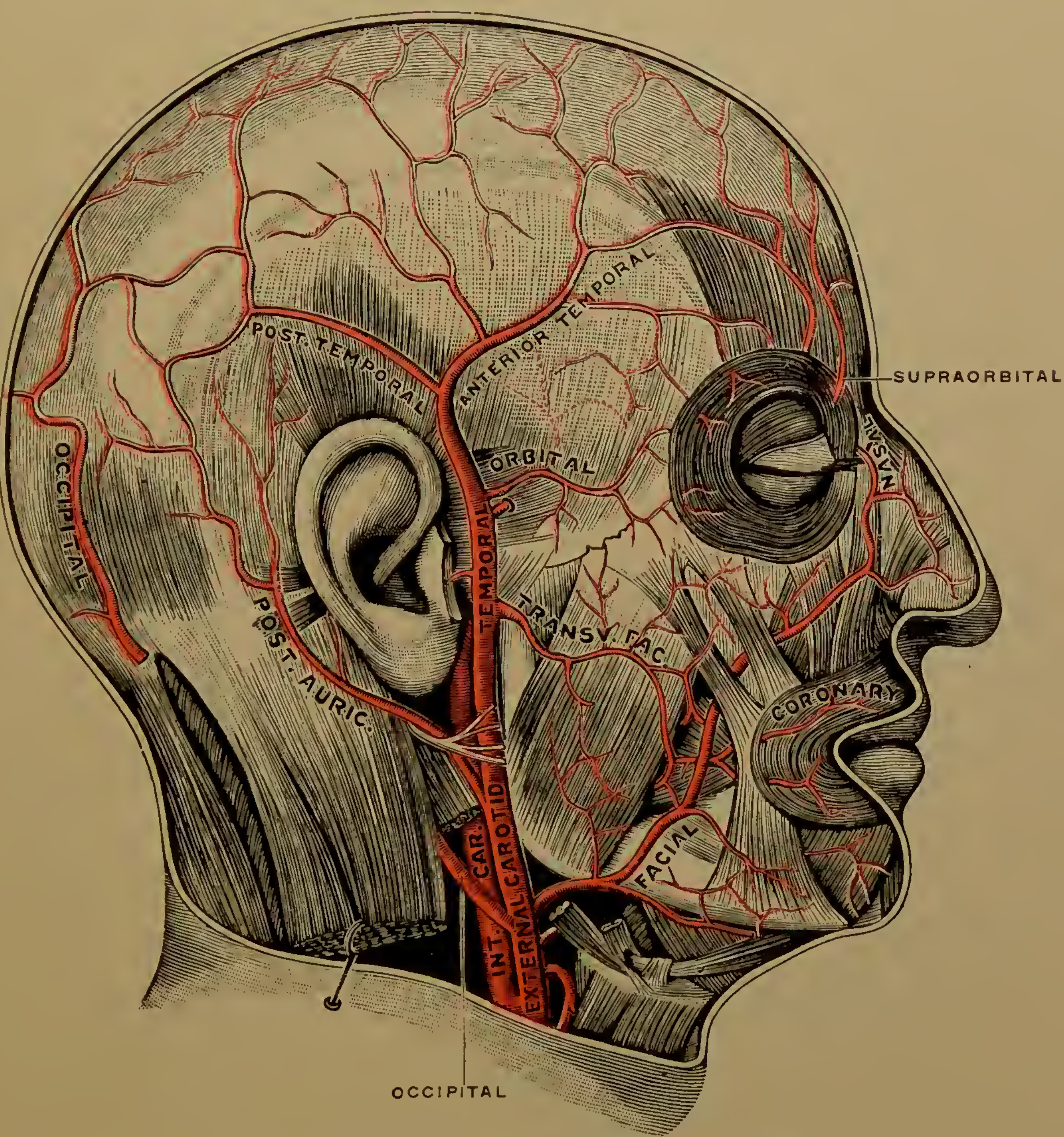


FIG. 476.—Superficial arteries of the head. (Testut.)

temporal bone, occupying a groove on its inferior surface. The vessel is here covered by the digastric and stylo-hyoid muscles, and crosses the internal carotid, the internal jugular vein, and the vagus nerve; it then continues upward and backward beneath the muscles attached to the superior curved line of the occiptal bone and the space between this and the inferior curved line, becomes superficial by piercing the trapezius or the fascia between the occipital attachments of the trapezius and sterno-cleido-mastoid, and then runs forward in the scalp tissue to the vertex of the skull, anastomosing with the branches of the temporal and posterior auricular.

Variations.—The occipital is in rare cases a branch of the internal carotid; sometimes it is given off from the inferior thyroid.

Branches.—The muscular, the sterno-mastoid, the posterior auricular, the

meningeal, the arteria princeps cervicis, and the terminal. *Muscular* branches are given off to the muscles with which it is in contact; one large muscular branch, the *sterno-mastoid*, is distributed to the sterno-cleido-mastoid, and is here accompanied by the spinal accessory nerve. The *auricular* branch supplies the posterior portion of the external ear. The *meningeal* branch is one of the posterior meningeal arteries, and enters the skull through the jugular foramen. The *arteria princeps cervicis* passes downward, and, deeply situated, divides into two sets of branches, one anastomosing with the deep cervical branch of the superior intercostal artery, the other with the superficial cervical branch of the transverse cervical. The *terminal* branches are distributed to the soft parts of the occipital region.

The Posterior Auricular Artery (Fig. 476) springs from the posterior surface of the external carotid, passes upward and backward beneath the parotid gland to a groove between the external meatus and the mastoid process, where it divides into two branches: the *mastoid*, supplying the scalp-tissue over the mastoid process, and anastomosing with the occipital; and an *auricular*, supplying the back of the ear, and anastomosing with branches of the temporal.

Variations.—The posterior auricular artery is sometimes a branch of the occipital. On the other hand, it is sometimes a vessel much larger than the occipital, being distributed to the region usually supplied by the occipital and temporal arteries.

Branches.—In addition to the two terminal branches, the auricular and mastoid, already sufficiently described, the artery gives off a *stylo-mastoid* branch, which enters the stylo-mastoid foramen, and supplies branches to the mastoid cells, tympanum, and internal ear.

The Ascending Pharyngeal Artery arises from the dorso-mesial surface of the external carotid, within half an inch of its origin from the common carotid, runs upward on the side of the pharynx and, covered by the internal carotid artery, to the base of the skull.

Variations.—The ascending pharyngeal may be a branch of the internal carotid or common carotid.

Branches.—The branches of the ascending pharyngeal are the prevertebral, the pharyngeal, the palatine, the tympanic, and the meningeal. The *prevertebral* branches supply the anterior recti and the longus colli muscles, and the nerves and lymph-nodes of this region. The *pharyngeal* branches supply the pharynx, tonsil, and soft palate. The *palatine* is distributed to the velum pendulum. The *tympanic* runs to the inner wall of the drum of the ear. The *meningeal* are several small vessels entering the skull through the jugular foramen, the anterior condylar foramen, and the foramen lacerum medium, and distributed to the dura.

The Temporal Artery (Fig. 476) (*superficial temporal*) is one of the terminal branches of the external carotid, and begins at a point a little below the condyle of the jaw. It passes upward through the substance of the parotid gland external to the zygoma, to a point from an inch and a half to two inches above the zygoma, and here divides into the anterior and posterior temporal arteries.

Variations.—The temporal artery is not frequently subject to variations from the usual type. It may be very small, and its place be taken by a large posterior auricular. The transverse facial may be of large size and take the place of a small facial artery.

Branches.—The branches of the temporal are its terminals, the anterior temporal and the posterior temporal, and the transverse facial, the middle temporal, the orbital, and the anterior auricular. The *transverse facial* (Fig. 448) is given off close to the point of origin of the temporal, passes forward across the face beneath the zygoma, on the surface of the masseter, and supplies the parotid gland, the masseter, and the skin of the face. The *middle temporal* is given off anteriorly, perforates the temporal fascia, and supplies the temporal muscle, anastomosing with the deep temporal branches of the internal maxillary. The *orbital* runs forward on the upper border of the zygoma to the orbit, supplying the orbicularis palpebrarum. The *anterior auricular* branch is distributed to the

anterior surface of the external ear. The *anterior temporal* winds forward and upward over the frontal bone, and supplies the scalp structures. In this position the artery is very superficially situated; its pulsations can be readily felt and often seen. The position of the artery is such that, in giving an anæsthetic the anæsthetizer can from this vessel feel the condition of the pulse. The *posterior temporal* passes backward and upward superficially in the scalp to the vertex of the skull, supplying the scalp in this region, and anastomosing with the occipital, the posterior auricular, and the vessel of the opposite side. Besides these principal branches smaller ones are given off to the temporo-mandibular articulation, to the parotid gland, and to the masseter.

The Internal Maxillary Artery (Figs. 477, 478), the vessel which nourishes the deep parts of the face, is one of the terminal branches of the external carotid.

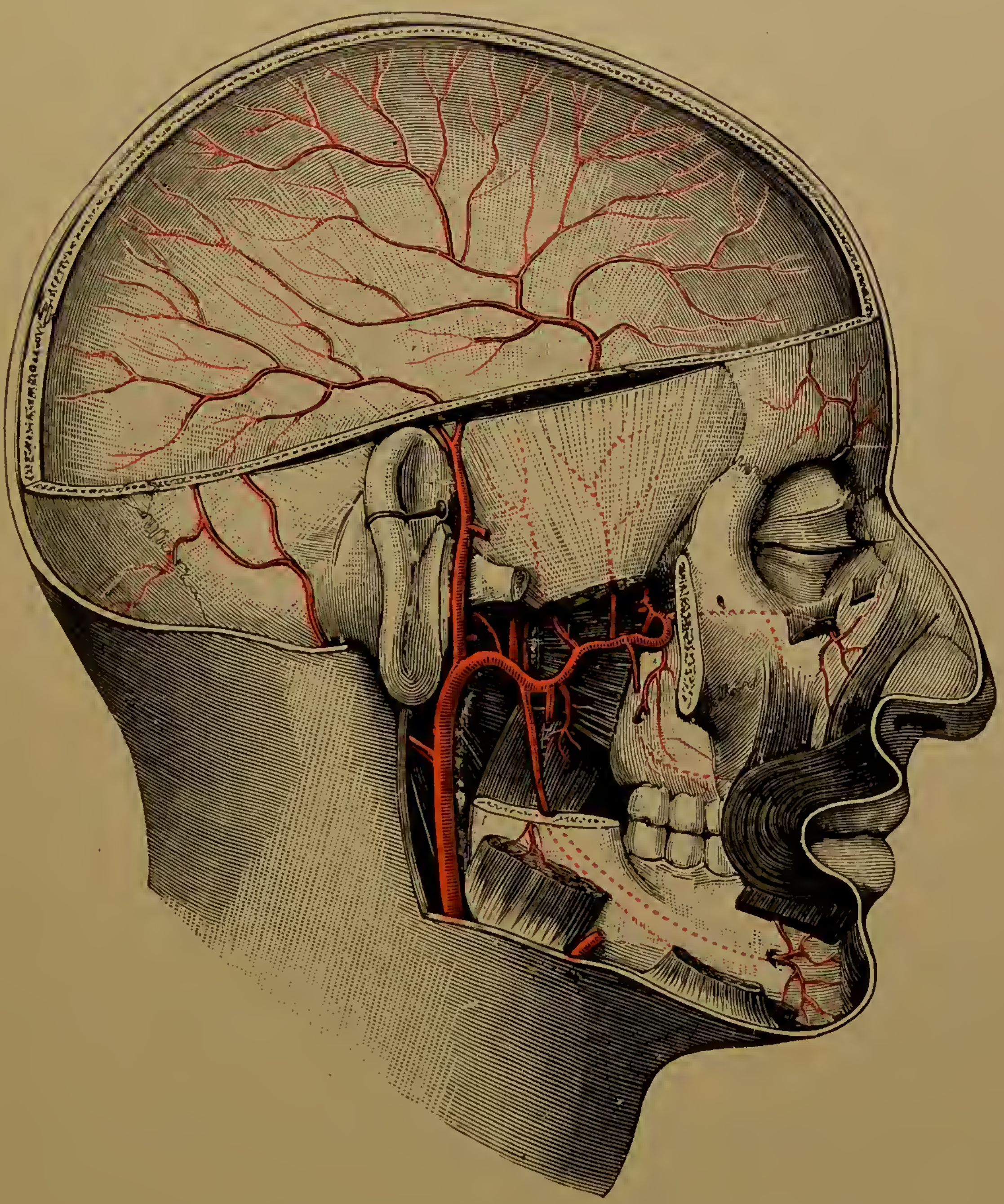


FIG. 477.—Internal maxillary artery. See Fig. 478. (Testut.)

It begins a little below the condyle of the jaw, in the substance of the parotid gland, whence it passes inward and forward to the spheno-maxillary fossa. It is divided into three portions, a maxillary, a pterygoid, and a spheno-maxillary. The *maxillary portion* lies below the external pterygoid muscle; the *pterygoid portion* lies on the outer surface of that muscle; the *spheno-maxillary portion* is in the spheno-maxillary fossa.

Variations.—The internal maxillary in rare cases is given off as a branch from the facial; the number of branches varies considerably, as two or more often arise by a common trunk.

Branches.—From the first or *maxillary portion* of the vessel are given off the

tympanic, the middle meningeal, the small meningeal, and the inferior dental arteries. The *tympanic* passes through the Glaserian fissure to the tympanum, which it aids in supplying. It gives a *deep auricular* branch to the skin of the external meatus. The *middle meningeal* enters the skull through the foramen spinosum, occupies a groove in the great wing of the sphenoid, passes upward and outward, and divides into an anterior and posterior branch. These branches groove the inner surface of the bone, running between the bone and the dura, and furnish the principal arterial supply of the latter. The *small meningeal* artery passes through the foramen ovale into the cranial cavity, and supplies the Gasserian ganglion and contiguous dura. The *inferior dental* (*mandibular*) is a large branch which passes downward to the inferior dental foramen, which it enters with the inferior dental nerve, running forward in the inferior dental canal to supply the mandible and teeth. Before entering the foramen the artery gives off the mylohyoid branch, which is distributed to the mylohyoid muscle, and occupies the mylohyoid groove on the internal surface of the mandible. The artery gives off branches to each tooth, and opposite the mental foramen a *mental* branch, which passes forward to supply the structures of the chin.

The branches of the *pterygoid portion* of the internal maxillary artery supply the muscles of mastication. They are the *deep temporal* (*posterior* and *anterior*),

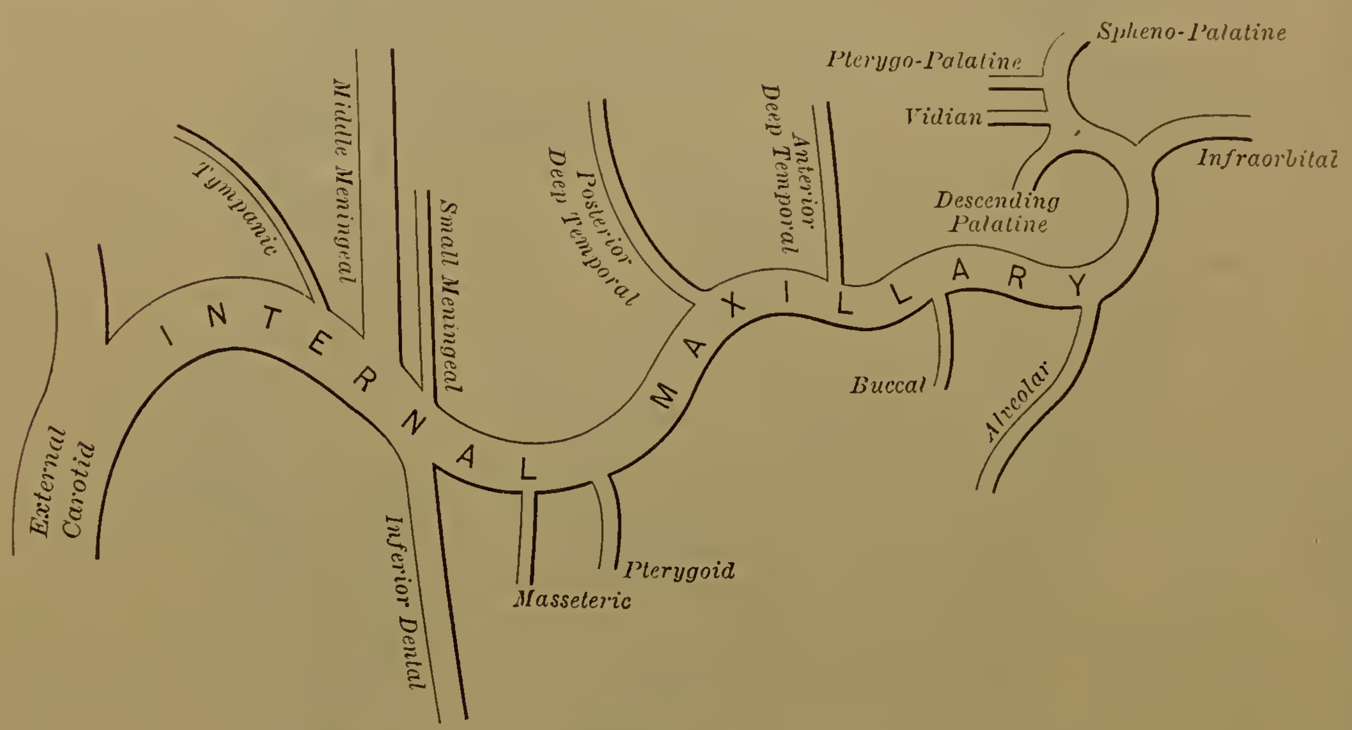


FIG. 478.—Diagram of the internal maxillary artery and its branches.

the *masseteric*, the *pterygoid*, and the *buccal*, and carry blood to the temporal, the masseter, the internal and external pterygoids, and the buccinator.

The branches from the third or *spheno-maxillary portion* are the alveolar, the infraorbital, the descending palatine, the Vidian, the pterygo-palatine, and the spheno-palatine. The *alveolar* (*posterior dental*) supplies the posterior portion of the alveolar process of the maxilla, the antrum, the gums, and the molar and bicuspid teeth. The *infraorbital* passes with the infraorbital nerve along the infraorbital groove and canal, makes its appearance on the face at the infraorbital foramen, and supplies here the soft tissues over the superior maxillary bone, anastomosing with branches from the facial. In the orbit the artery gives off muscular branches, which supply the inferior oblique and inferior rectus muscles, and in the canal branches to the canine and incisor teeth. The *descending palatine* passes with the descending branches of Meckel's ganglion down the posterior palatine canal to the mouth, then runs in a groove on the under surface of the hard palate forward to the anterior palatine canal, where it anastomoses with the naso-palatine artery, and supplies the gums, mucous membrane, and glands of the hard palate. The *Vidian* passes backward through the Vidian canal to be distributed to the pharynx and Eustachian tube. The *pterygo-palatine* passes back-

ward through the pterygo-palatine canal, and also is distributed to the upper part of the pharynx. The *spheno-palatine* passes through the spheno-palatine foramen into the nasal cavity. It divides into two branches, the *naso-palatine*, which runs in a groove of the vomer downward and forward to the anterior palatine foramen, where it anastomoses with the descending palatine artery; and an *external* branch, which supplies the mucous membrane of the outer wall of the nasal cavity, and the maxillary, ethmoidal, and sphenoidal sinuses.

The Internal Carotid Artery.

The *internal carotid* (Fig. 470) artery springs from the common carotid opposite the superior border of the thyroid cartilage, runs upward in front of the transverse processes of the upper three or four cervical vertebræ to the carotid canal in the petrous portion of the temporal bone, through the canal to its internal opening, enters the cranial cavity, and then passes into the cavernous sinus, in which it is covered by the lining membrane of that channel. It leaves the sinus at the inner side of the anterior clinoid process, and passes to the Sylvian fissure, where it breaks up into its terminal branches. The artery is distributed mainly to the brain and eye. It is divided into four portions: a cervical, a petrous, a cavernous, and a cerebral.

The cervical portion is that extending from its origin to the lower opening of the carotid canal.

Relations (Fig. 472).—*In front*, below, is the external carotid artery, overlapped by the sterno-cleido-mastoid; higher up in order are the digastric and the stylo-hyoid muscles, the hypoglossal nerve, the occipital and the posterior auricular arteries, the glosso-pharyngeal nerve, the stylo-pharyngeus and the stylo-glossus muscles. *Behind* are the rectus capitis anterior major, the superior cervical ganglion, and the superior laryngeal nerve; and, near the skull, the ninth, tenth, eleventh, and twelfth cranial nerves between the artery and the internal jugular vein. *At the outer side* are the internal jugular vein and the vagus nerve—the latter posterior. *At the inner side* are the pharynx with the tonsil, the superior laryngeal nerve, and the ascending pharyngeal artery.

Variations.—The internal carotid sometimes arises directly from the arch of the aorta. It is in rare cases absent. It very exceptionally gives off branches in the neck, which are usually the occipital and ascending pharyngeal.

Branches.—As a rule, the internal carotid gives off no branches of importance in the neck. (See Variations.)

The petrous portion of the vessel is that part contained in the carotid canal. Here the artery makes two sharp turns, which are supposed to diminish the arterial pressure. Its course is successively upward, forward, and inward and upward. From this portion of the artery a small branch is given off to the tympanum.

The cavernous portion is that part of the vessel which is in the cavernous sinus. Here the vessel gives off the following branches: the arteriæ receptaculi, the anterior meningeal, and the ophthalmic. The *arteriæ receptaculi* are small vessels which supply the pituitary body and the Gasserian ganglion. The *anterior meningeal* artery is distributed to the dura of the anterior fossa at the base of the skull.

The Ophthalmic Artery (Fig. 479) passes with the optic nerve through the optic foramen into the orbit. It goes first forward and outward, then crosses the optic nerve and passes forward and inward, runs along the inner wall of the orbit, beneath the inner portion of the orbital margin, leaves the orbit, and terminates by dividing into the frontal and nasal arteries. In its course the ophthalmic artery gives off branches to the walls and contents of the orbit. These branches are the central artery of the retina, the ciliary arteries, the lachrymal, the muscular, the supraorbital, the ethmoidal, and the palpebral. The *central artery of the retina* is given off from the ophthalmic near the optic foramen. It accompanies

the optic nerve, and is distributed to the retina. The branches of this vessel can be well seen in ophthalmoscopic examinations of the retina. The *ciliary* arteries are divided into three sets—the long, short, and anterior ciliary arteries. The *short ciliary* arteries are eight or ten in number, pierce the sclerotic coat near the optic nerve, and run forward to supply the choroid. The *long ciliary* arteries, two in number, one on each side, pierce the sclera some distance from the optic nerve, and run forward to supply the ciliary body and iris. The *anterior ciliary* arteries are branches of the muscular branches of the ophthalmic. They perforate the sclera near the cornea and supply the iris. The anterior and long ciliary arteries form an anastomosis around the outer margin of the iris, and another around its free margin. The *lachrymal* artery arises from the ophthalmic external to the optic nerve, passes forward and outward to the lachrymal gland, which it supplies, and, leaving the gland, sends small branches to the eyelids, known as *external palpebral* branches. *Muscular* branches are given off from various portions of the ophthalmic in its course to the muscles of the globe. The *supraorbital*

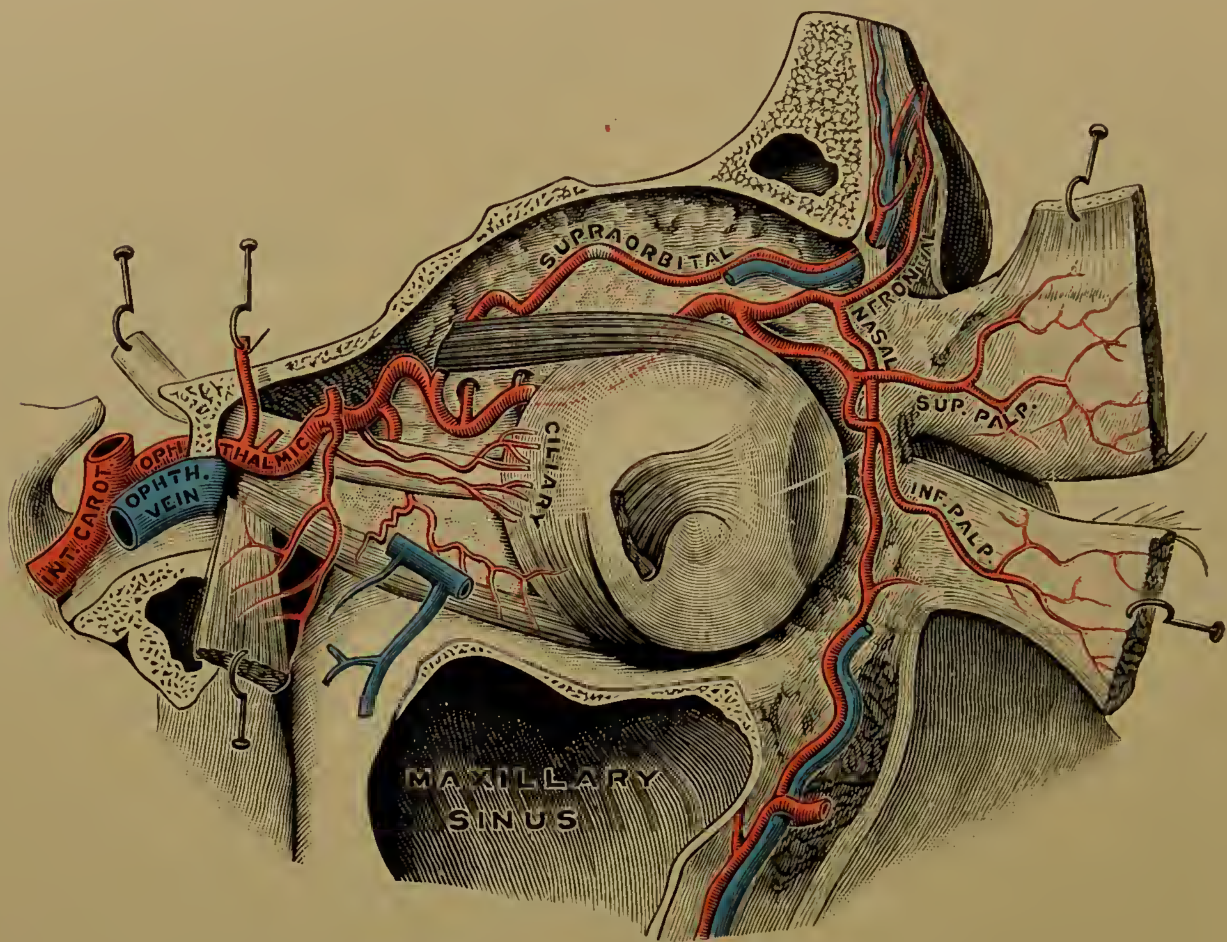


FIG. 479.—Arteries of the orbit. (Testut.)

artery is a vessel of some size, which runs along the roof of the orbit to the supraorbital notch. Leaving the orbit at this point, it courses upward in the muscles and integument of the forehead. The *ethmoidal* arteries, two in number, are given off from the ophthalmic opposite the anterior and posterior ethmoidal foramina. Entering the cranial cavity through these foramina they give off *anterior meningeal* vessels, supplying the dura in the anterior fossa at the base of the skull. The *anterior ethmoidal* is the larger, and, after giving off a meningeal branch, leaves the cranial cavity with the nasal nerve, passes through an opening in the cribriform plate to the nasal cavity, runs along the inner surface of the nasal bone, and supplies the tip of the nose. The *palpebral* arteries, two in number, the superior and inferior, supply the upper and lower lids. The *nasal* artery leaves the orbit above the inner canthus, and supplies the bridge of the nose, anastomosing with the angular branch of the facial. The *frontal* leaves the orbit at the upper and inner angle, winds up over the forehead near the median line, supplying the soft tissues in this region.

Variations.—The ophthalmic is sometimes situated beneath the optic nerve.

and on the inner side of the orbit throughout its entire course. It may be a branch of the middle meningeal, or even give origin to that vessel. Variations in the number and position of the branches as described frequently occur.

The cerebral portion of the internal carotid has for its branches the posterior communicating, the anterior choroid, the anterior cerebral, and the middle cerebral arteries. The *posterior communicating* passes backward to the posterior cerebral artery, a branch from the basilar, and forms the lateral portion of the circle of Willis. The *anterior choroid* passes outward and backward to the descending horn of the lateral ventricle, where it supplies the choroid plexus, the velum interpositum, the hippocampus, and the fimbria. The *anterior cerebral* runs forward and inward to the great longitudinal fissure between the hemispheres. In this fissure the artery lies close to its opposite mate, and connecting them is a short trunk, the *anterior communicating*. The artery winds over the anterior extremity of the corpus callosum to reach its superior surface. It gives off branches to the anterior perforated space, to the under surface of the frontal lobe, and the mesial surface of the hemisphere, and anastomoses with the posterior cerebral artery. The *middle cerebral* (Sylvian) artery passes forward and outward to the fissure of Sylvius, and then runs along the fissure to the insula and the external surface of the hemisphere. In its course it gives branches, which enter the anterior perforated space, and supply the ganglia and other structures in the floor of the lateral ventricle. One of these vessels is of special interest, the *lenticulo-striate* artery, called also Charcot's *artery of cerebral hemorrhage*, because it is a very common site of arterial rupture in cases of apoplexy. This vessel is situated between the external capsule and the corpus striatum. The cortical brain substance of the motor area is also supplied by the middle cerebral artery, and here arterial lesions are common and often produce localizing symptoms. After discussing the vertebral artery, which with the internal carotid supplies the encephalon, the arterial supply of the brain will be given more in detail.

ARTERIES OF THE UPPER EXTREMITY.

From the brachio-cephalic on the right side and from the arch of the aorta on the left begins a great trunk which extends to below the bend of the elbow, presenting in its course no intrinsic markings by which it can be divided. For the sake of convenience, however, certain extrinsic structures have been selected, by which this long trunk is divided into three portions. The first extends from the origin of the vessel to the horizontal level of the outer border of the first rib, and is called the subclavian artery; the second reaches from the first rib to the lower border of the teres major muscle, and is known as the axillary artery; and the third runs from the teres major to a point half an inch below the bend of the elbow, and is named the brachial artery.

THE SUBCLAVIAN ARTERY.

The *subclavian* ("under the clavicle") *artery* (Fig. 480) takes its origin on the left side from the arch of the aorta, on the right side from the brachio-cephalic artery. Each vessel passes upward and outward into the neck, and then arches downward and outward to terminate in the axillary, at the horizontal level of the outer border of the first rib. The subclavian artery is divided into three portions, according to its situation with reference to the scalenus anterior muscle. The first portion extends from the origin of the vessel to the inner border of the scalenus anterior muscle; the second portion lies behind this muscle; and the third portion runs from the outer border of the muscle to the outer border of the first rib. The first portions of the subclavian arteries differ, and must be described separately. A single description will answer for the second and third portions of both arteries.

The first portion of the left subclavian is deeply situated in the thorax. Springing from the transverse portion of the aortic arch farther back than the other great arteries, it passes upward and a little forward to the mesial edge of the left scalenus anterior, where this muscle is inserted into the first rib.

Relations.—*In front* at its lowest part are the left brachio-cephalic vein and the left vagus nerve; high up the left phrenic nerve crosses the artery; toward the right is the left carotid artery; and elsewhere are the internal jugular, vertebral, and subclavian veins, and cardiac sympathetic branches; the left lung with its pleura overlaps these structures. *Behind* are the gullet, thoracic duct, inferior cervical sympathetic ganglion, and longus colli muscle. *At the left* is the left lung with its pleura. *At the right* above are the gullet and thoracic duct; below are the trachea and recurrent laryngeal nerve.

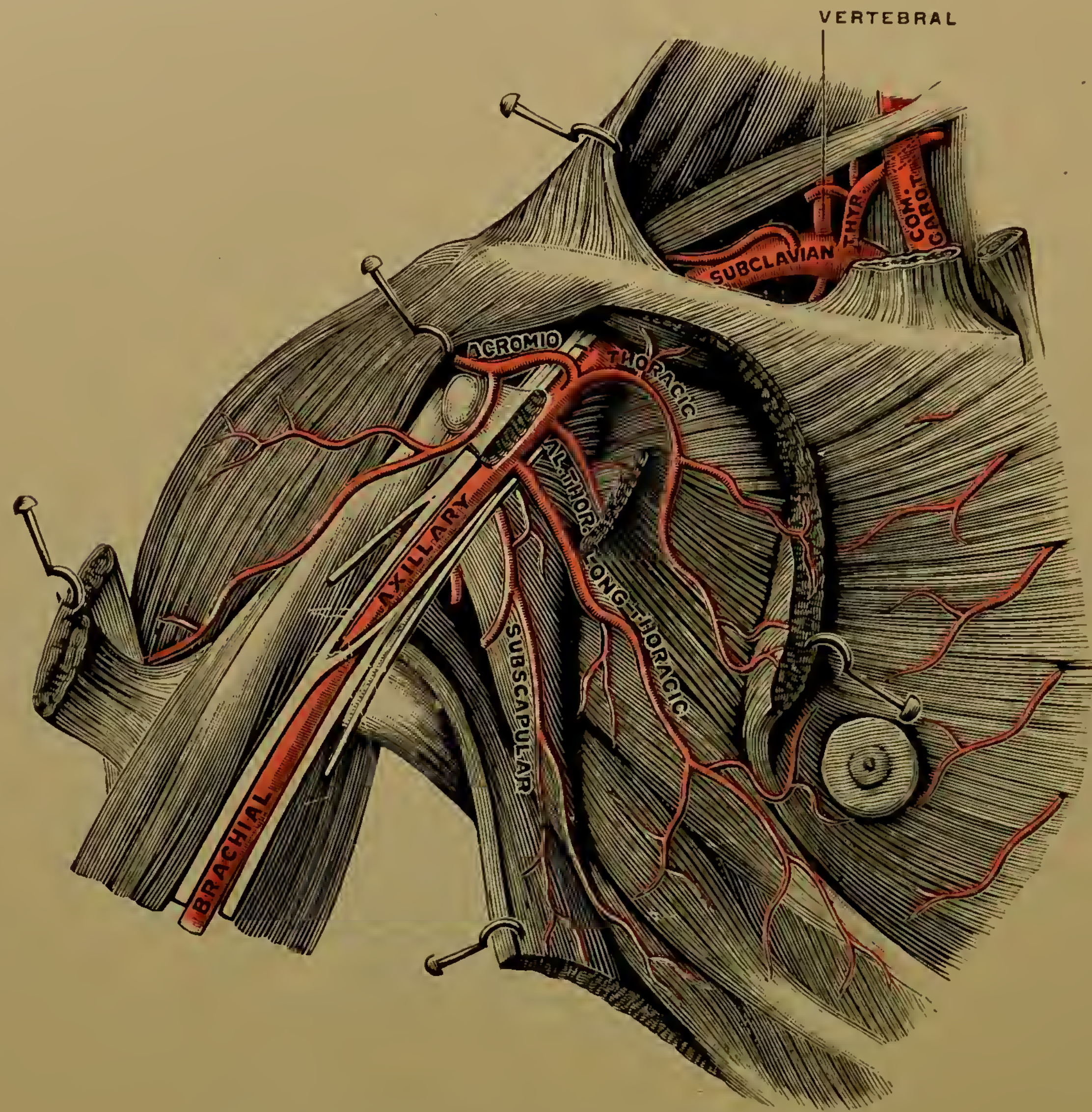


FIG. 480.—Subclavian and axillary arteries. (Testut.)

The first portion of the right subclavian takes its origin from the brachiocephalic artery, and extends upward and outward to the inner border of the scalenus anterior. It is about an inch and a quarter long.

Relations (Fig. 481).—*In front* are the right internal jugular and vertebral veins, the right vagus and phrenic nerves, the sympathetic nerve and its superior cardiac branches. *Behind* are the right lung with its pleura, the recurrent laryngeal and sympathetic nerves. *Below* are the lung and pleura, and the recurrent laryngeal nerve.

The second portion of the subclavian is behind the scalenus anterior. It is three-quarters of an inch long.

Relations.—*In front* is the scalenus anterior, which separates the artery from the subclavian vein (the latter being on a lower level), and from the phrenic nerve. *Behind* are the apex of the lung covered by pleura, and the scalenus medius. *Above* is the brachial plexus. *Below* is the lung with its pleura.

The third portion of the subclavian extends from the outer border of the scale-

nus anterior to the outer border of the first rib. It is the most superficial portion of the artery, and is in the subclavian triangle.

Relations.—*In front* it is in contact with the posterior layer of the cervical fascia, the suprascapular artery, the external jugular vein, and cervical veins

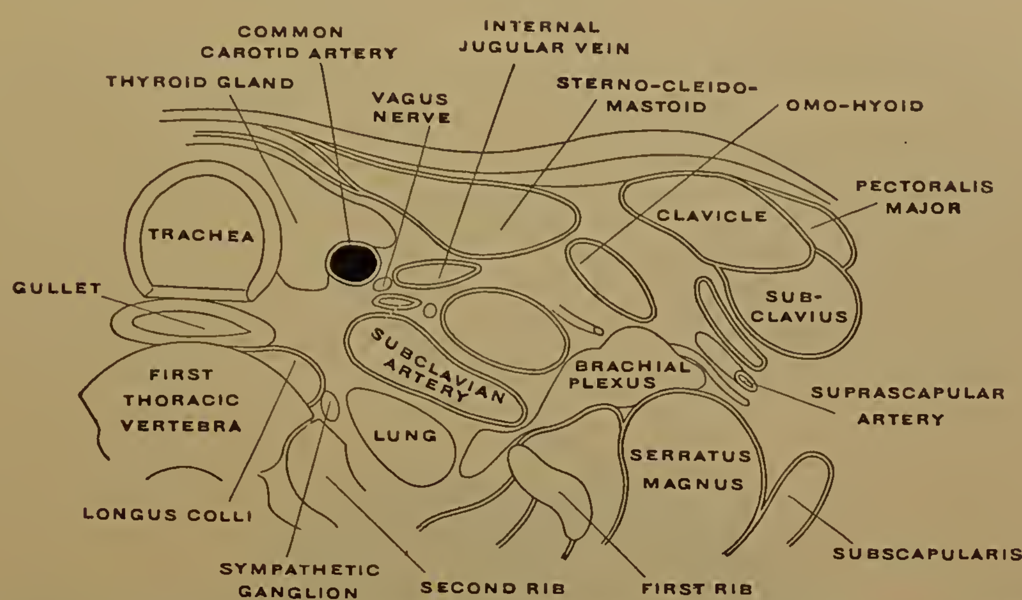


FIG. 481.—Horizontal section through the first thoracic vertebra—upper surface of lower segment. The ventral and dextral part of the section is shown. (Braune.)

which are tributary to it. *Behind* are the scalenus medius and part of the brachial plexus. *Above* are the brachial plexus and the posterior belly of the omo-hyoid muscle. *Below* is the first rib.

Variations.—The subclavian is sometimes on both sides a direct trunk from the aortic arch, or on both sides a branch from a right and left brachio-cephalic

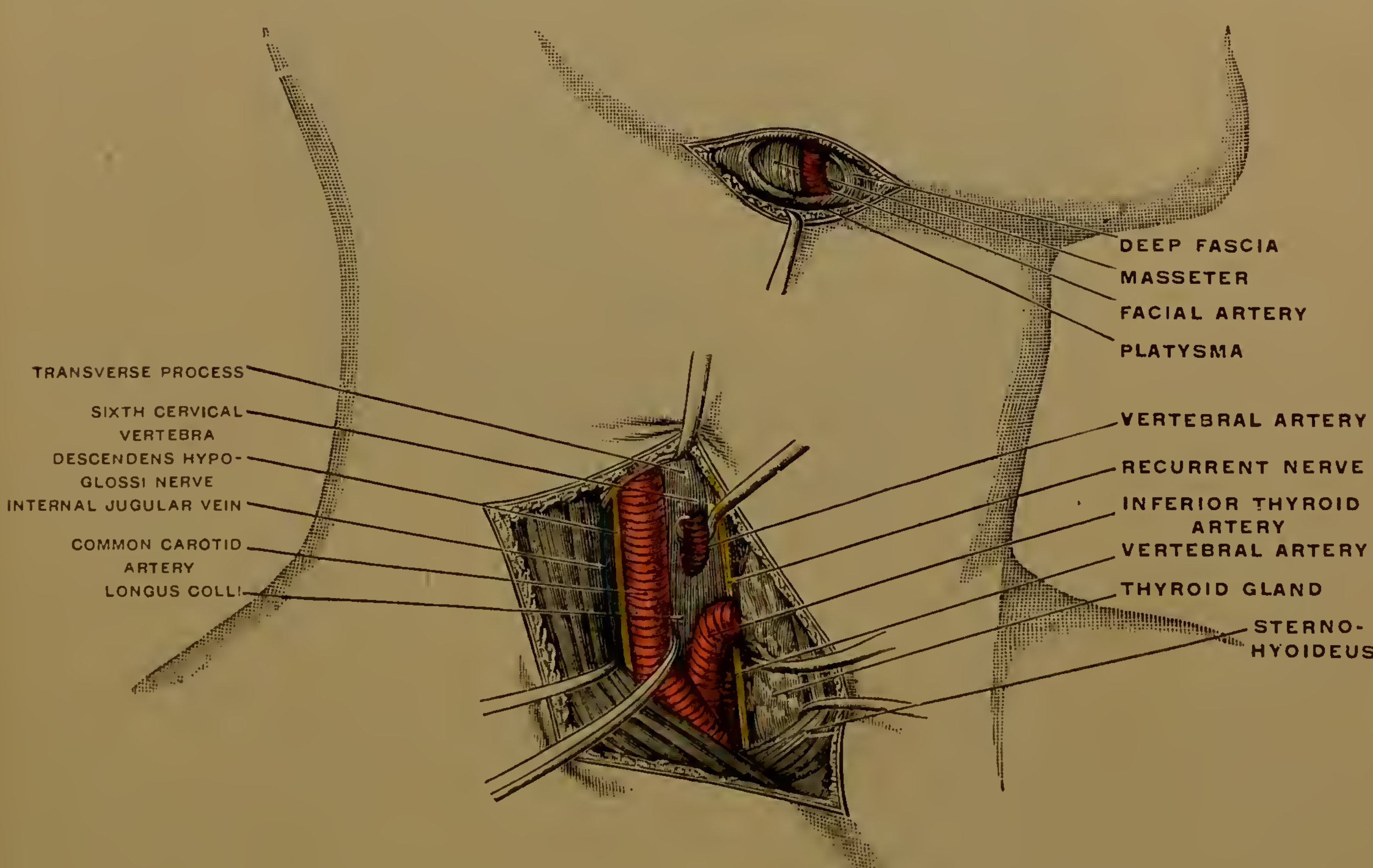


FIG. 482.—Surgical relations of the facial, vertebral, and inferior thyroid arteries. (Kocher.)

artery. The vessel is usually at its high point in the neck a half inch above the clavicle, but sometimes it rises considerably higher; and it may be beneath the clavicle entirely.

Branches.—These are usually four in number, namely, the vertebral, the internal mammary, the thyroid axis, and the superior intercostal. All but the last spring

from the first portion; and this one does so in many cases, but more frequently comes from the second. The posterior scapular very often is given off from the third portion.

The Vertebral Artery.

The *vertebral* (Fig. 470), so called from its situation in the cervical vertebræ, is the largest branch of the subclavian, from the posterior surface of which it is given off. Its blood is principally distributed to the spinal cord, the cerebellum, and the posterior part of the cerebral hemispheres. It passes up between the scalenus anterior and the longus colli, and behind the internal jugular and vertebral veins, to the costo-transverse foramen of the sixth cervical vertebra, and goes upward through this and the corresponding foramina of the vertebræ above; it then runs backward behind the articular process of the atlas, and over the

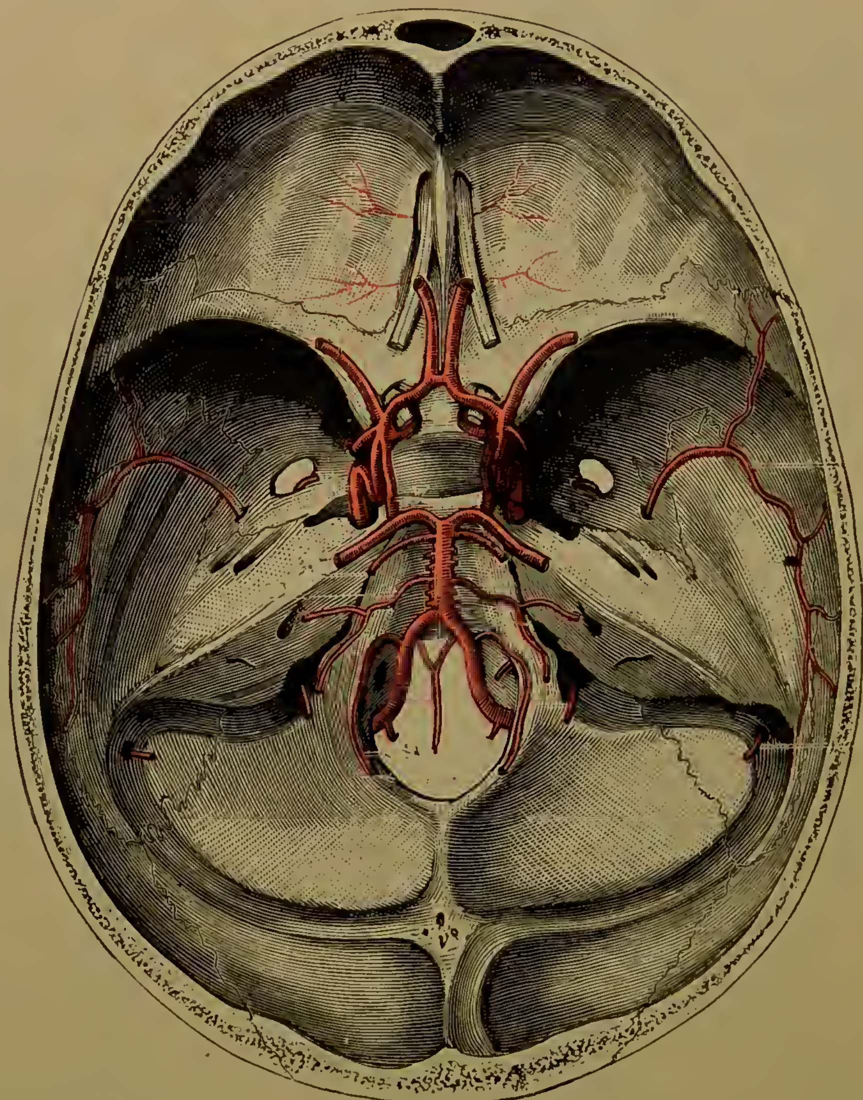


FIG. 483.—Arteries at the base of the brain, seen in their relations to the skull. See Fig. 484, Key. (Testut.)

upper surface, and enters the cranial cavity through the foramen magnum. On the basilar process of the occipital the vertebral arteries of the two sides unite at the lower border of the pons, and thus form the basilar artery.

Variations.—The vertebral may arise from the common carotid or from the arch of the aorta. It may pass through all of the costo-transverse foramina of its side, or none below the third.

Branches.—The branches are considered in two sets—the cervical and the cranial. Those in the neck are the lateral spinal and the muscular. The *lateral spinal* enter the spinal canal through the intervertebral foramina, and supply the cord, its membranes, and the vertebræ. The *muscular* are distributed to the deep muscles of the neck.

The cranial branches (Figs. 483, 484) are the posterior spinal, the anterior spinal, the posterior inferior cerebellar, the bulbar, and the posterior meningeal.

The *posterior spinal* runs down beside the oblongata, reaches the back of the cord, and descends behind the dorsal roots of the spinal nerves to the cauda equina, anastomosing freely all the way with arteries entering the canal at the side. The *anterior spinal* joins its opposite fellow near the foramen magnum, and the resulting vessel runs down ventrally the length of the cord, inosculating with vessels which enter the canal through the intervertebral foramina. The *posterior inferior cerebellar*, the largest branch, is distributed to the hind and under portions of the cerebellum, and in the fourth ventricle. The *bulbar* are small branches to the oblongata, as the name implies. The *posterior meningeal*, of small size, are distributed to the parietes of the posterior cranial fossa.

The **Basilar Artery** (Figs. 483, 484), so called from its situation at the base of the cranium, is formed by the union of the vertebral arteries, and supplies considerable portions of the encephalon in its lower levels. It runs forward and upward in the groove on the ventral surface of the pons, and divides into the posterior cerebral arteries. In its course it gives off as branches the transverse, the anterior inferior cerebellar and superior cerebellar arteries. The *transverse* or pontal arteries supply the pons, and one branch enters the internal auditory meatus with the facial and auditory nerve, and runs to the labyrinth of the ear. The *anterior inferior cerebellar* arteries supply the anterior portion of the inferior surface of the cerebellum. The *superior cerebellar* arteries wind backward and upward to the upper surface of the cerebellum, which they supply. All of these arteries to the brain anastomose freely with one another, and with branches of the vertebral.

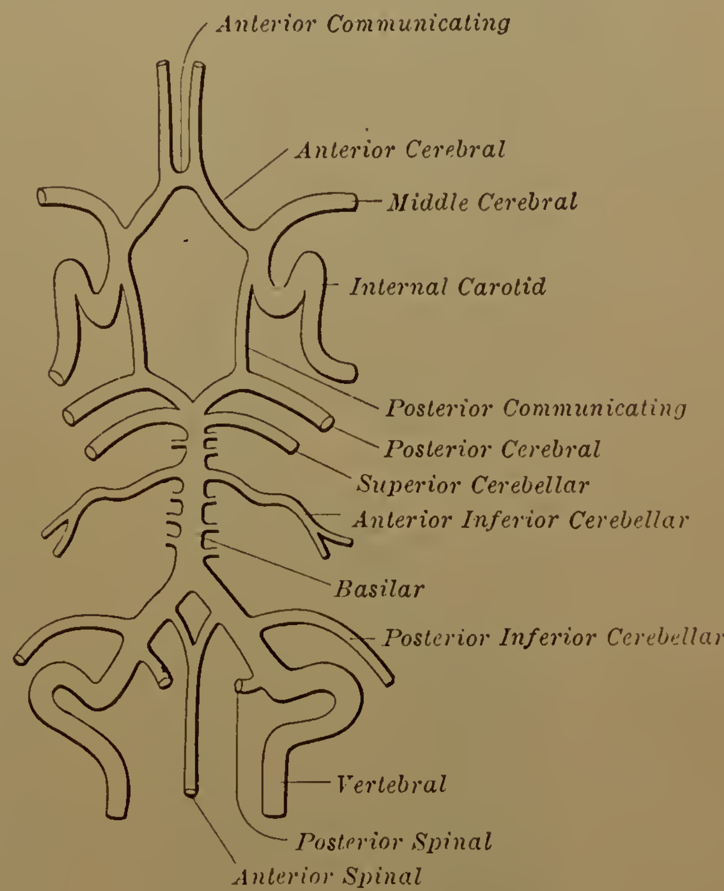


FIG. 484.—Key to Fig. 483.

The terminal branches of the basilar, the *posterior cerebral* arteries, are vessels of large size, which anastomose with the posterior communicating to complete the circle of Willis behind. They pass to the under surface of the occipital lobes of the cerebral hemispheres, their terminal branches supplying these and the neighboring temporal lobes. Numerous small branches (*ganglionic*) are given off in the course of these arteries to the thalami, great ganglia at the base of the brain, passing through the posterior perforated space; and others (*choroid*) go through the transverse fissure to the velum interpositum.

The **Circle of Willis** is an anastomosis formed in front by the anterior cerebral arteries and the anterior communicating which unites them; behind by the posterior cerebral; and laterally by the internal carotid and posterior communicating. From the cerebral arteries close to the circle of Willis deep ganglionic branches are given off which penetrate the brain substance, and are distributed to the great basal ganglia and the contiguous structures. Beyond this the vessels supply the cortex. A point of practical importance in this connection is the fact that the arteries which supply the brain are terminal arteries, and that there is no anastomosis between the vessels going to the ganglia and central structures of the brain and those supplying the cortex. As a result, whenever occlusion of an artery of the brain occurs, the portion of cerebral tissue supplied by the vessel beyond the point of obstruction has its arterial supply permanently cut off, and disorganization ensues.

The Internal Mammary Artery.

The *internal mammary* (Fig. 485) is named from its deep situation and its distribution in part to the milk-gland. Besides this destination it supplies to some extent muscles in the chest and abdomen, the sternum, the anterior mediastinum, and the pericardium. It is given off from the under surface of the subclavian, passes from the neck into the thorax behind the first costal cartilage, and then runs down in front of the pleura half an inch away from the side of the sternum to the sixth intercostal space, where it divides into the superior epigastric and musculo-phrenic arteries.

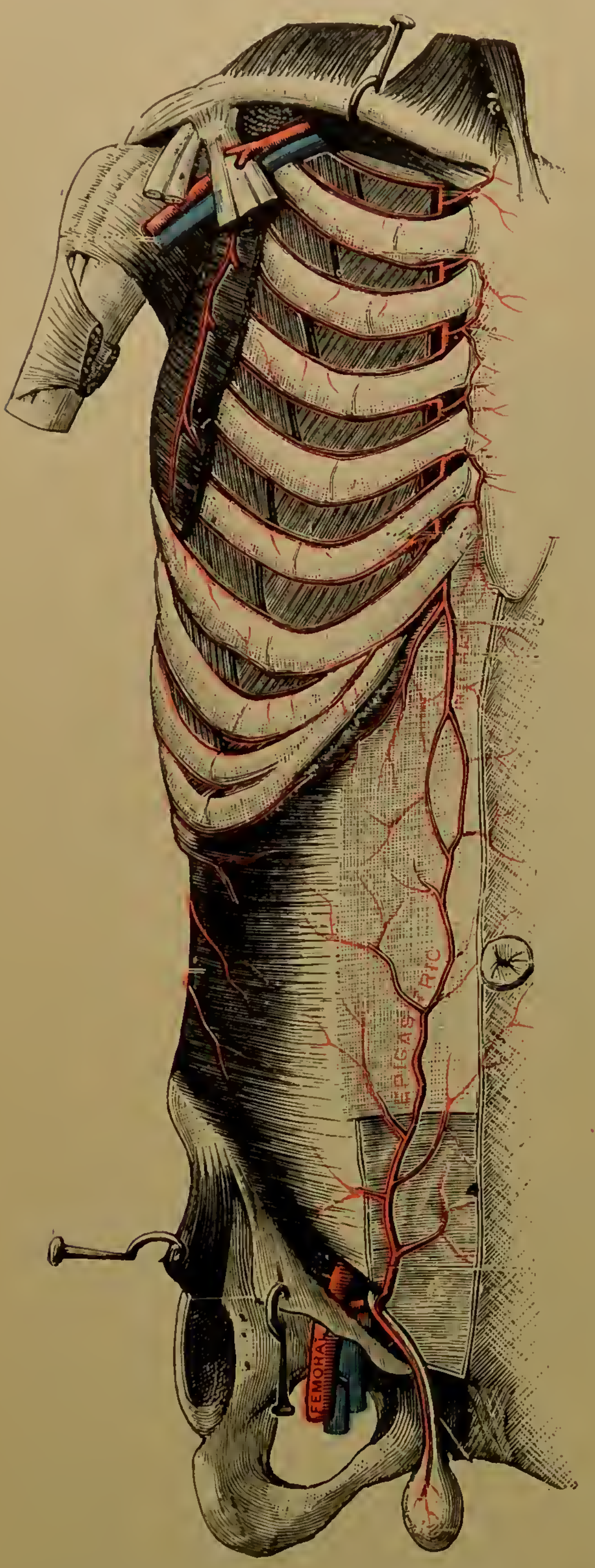


Fig. 485.—Internal mammary and deep epigastric arteries. (Testut.)

Branches.—The branches given off in its course are the superior phrenic, the mediastinal, the pericardial, the sternal, the anterior intercostal, and the perforating. The *superior phrenic* (comes nervi phrenici) accompanies the phrenic nerve, and is distributed to the diaphragm. The *mediastinal* branches supply the structures in the anterior mediastinum. The *pericardial* go to the upper portion of the pericardium, and the *sternal* to the breast-bone and triangularis sterni. The *anterior intercostal*, one to each of the upper five or six spaces, supply the neighboring portions of these spaces, each artery dividing into an upper and a lower branch, which inosculate with the intercostals which come from the aorta. The *perforating* pierce the intercostal muscles in the upper five or six spaces, and pass forward and outward to the pectoralis major, the mammary gland, and the skin. The terminal branches are the musculophrenic and superior epigastric. The *musculo-phrenic* winds outward and downward along the inner surface of the costal arch, and opposite each one of the lower intercostal spaces it gives off an intercostal branch, and sends also a number of muscular branches to the diaphragm and abdominal muscles. The *superior epigastric* descends into the abdominal wall, at first occupying a position between the rectus muscle and its posterior sheath, then passes into the substance of the rectus, and anastomoses with the deep epigastric artery. It sends branches also to the oblique muscles of the abdomen and to the diaphragm.

The Thyroid Axis.

The *thyroid axis* (Fig. 470, THY.) is so called from the distribution of its largest branch to the thyroid gland. It supplies many structures in the neck and shoulder. It is a short, wide vessel, arising from the antero-superior surface of the first portion of the subclavian, and it divides into three diverging branches, the inferior thyroid, the suprascapular, and the transverse cervical.

The Inferior Thyroid Artery passes upward and then inward in front of the vertebral and behind the common carotid to the lateral lobe of the thyroid gland. Its chief distribution is to structures in the ventral part of the neck. The recurrent laryngeal nerve passes sometimes in front and sometimes behind the artery, in intimate relation to it.

Variations.—The inferior thyroid may spring from the vertebral, the common carotid, or the subclavian.

Branches of the inferior thyroid are the glandular, muscular, ascending cervical, inferior laryngeal, tracheal, and œsophageal. The *glandular* are terminal, and ramify in the thyroid gland, anastomosing with branches of the other thyroid arteries. The *muscular* supply the muscles in the immediate neighborhood. The *ascending cervical* goes upward between the scalenus anterior and the rectus capitis anterior major, and anastomoses with the occipital, vertebral, and ascending pharyngeal. It supplies muscles in its course, and sends spinal branches to the vertebræ and cord. The *inferior laryngeal* accompanies the recurrent laryngeal nerve, and supplies the muscles and mucous membrane of the larynx. The *tracheal* and *œsophageal* are distributed to the organs suggested by their names.

The Suprascapular Artery supplies various structures of the shoulder. It passes outward from the thyroid axis to the upper border of the scapula, running almost parallel with the clavicle, crosses the transverse ligament into the supraspinous fossa, where it supplies the supraspinatus muscle, passes behind the neck into the infraspinous fossa, and ramifies in the infraspinatus. It anastomoses with the posterior scapular and dorsal scapular arteries.

Variations.—It sometimes arises directly from the subclavian, occasionally from the axillary.

Branches, in addition to the terminal branches already given, are, *muscular* to contiguous muscles, *suprasternal* to the integument over the sterno-clavicular articulation, *nutrient* to the clavicle, *supra-acromial* to the tissues over the acromion, and *subscapular* to the subscapularis muscle.

The Transverse Cervical Artery (transversalis colli) passes outward and backward in front of the scaleni and the brachial plexus, under the anterior border of the trapezius to the levator scapulæ, where it divides into the superficial cervical and the posterior scapular. It is distributed to muscles of the shoulder and neck. The *superficial cervical* passes upward under the trapezius, supplying this muscle, the levator scapulæ, the splenius, and neighboring lymph-nodes. The *posterior scapular* passes downward along the vertebral border of the scapula to its inferior angle. In its course it is covered by the rhomboid muscles, and anastomoses with other scapular arteries—suprascapular, dorsal scapular, and subscapular.

Variation.—The posterior scapular is very often a separate branch from the third portion of the subclavian.

The Superior Intercostal Artery.

The *superior intercostal* is distributed chiefly to the first intercostal space. It springs from the postero-superior surface of the first or second portion of the subclavian. It runs back over the apex of the lung to the neck of the first rib, in front of which it then passes down to the first intercostal space, which it supplies after the manner of the aortic intercostals. Very often the artery is continued down to the second intercostal space, and supplies it like the first. Before it enters the thorax the artery gives off a *deep cervical* branch, which goes backward, and then runs up the neck between the complexus and semispinalis cervicis, supplying the muscles in its region, and inosculating with the cervical branch (princeps cervicalis) of the occipital.

Variations.—The superior intercostal is sometimes a branch of the thyroid axis. The deep cervical may be a branch from the subclavian or from the posterior scapular.

THE TRIANGLES OF THE NECK.

The quadrilateral surface of the neck, which is bounded below by the clavicle, above by the inferior border of the mandible and a line drawn from the angle of the jaw to the mastoid process, behind by the anterior border of the trapezius muscle, and in front by the median line of the neck, is divided by the sterno-cleido-mastoid muscle into two triangles, called the *anterior* and *posterior triangles* of the neck. These two triangles are subdivided, the posterior into two, the *occipital*, and the *subclavian*, by the posterior belly of the omo-hyoid; the anterior into three by the anterior belly of the omo-hyoid, and the two bellies of the digastric. These are called the *inferior carotid*, the *superior carotid*, and the *submaxillary* triangles (Fig. 422).

The boundaries of these triangles and their principal arterial contents are as follows:

The *occipital triangle* is bounded in front by the sterno-cleido-mastoid, behind by the trapezius, below by the posterior belly of the omo-hyoid, and contains the transverse cervical artery. The *subclavian triangle* is bounded in front by the sterno-cleido-mastoid, postero-superiorly by the hind belly of the omo-hyoid, below by the clavicle, and contains the subclavian artery. The *inferior carotid triangle* is bounded in front by the median line, dorso-inferiorly by the sterno-cleido-mastoid, dorso-superiorly by the anterior belly of the omo-hyoid, and contains the common carotid and inferior thyroid arteries. The *superior carotid triangle* has the sterno-cleido-mastoid behind, the anterior belly of the omo-hyoid in front, and the posterior belly of the digastric above. It contains the common, the internal, and the external carotids, and the beginnings of all of the branches of the last, except the terminals and the posterior auricular. The *submaxillary triangle* is formed above by the mandible and a line from its angle to the mastoid process, below in front by the anterior belly of the digastric, below behind by the posterior belly of the same. It contains the external carotid, the facial, the posterior auricular, and the internal carotid arteries.

THE AXILLARY SPACE.

The axilla or arm-pit is the wedge-shaped space between the inner surface of the arm and the side of the chest. It presents for examination as boundaries anterior, posterior, internal, and external walls, a base and an apex. The *anterior wall* is formed by the pectoral muscles; the *posterior wall* by the subscapularis, the latissimus, and the teres major muscles; the *inner wall* by the upper four ribs and intercostal spaces, covered by the serratus magnus muscle; and the *outer wall* by the humerus, covered by the coraco-brachialis and the biceps muscles. The *apex* corresponds to the small area above the first rib, from which the brachial plexus and the axillary artery and vein emerge. The *base* is formed by the integument and fascia which stretch across the arm-pit from the pectoralis major to the latissimus and teres major. Its contents are the axillary artery and its branches, the accompanying veins, the brachial plexus of nerves, lymph-nodes and vessels, and considerable fat and areolar tissue.

THE AXILLARY ARTERY.

The *axillary artery* (Fig. 487), named from its situation in the arm-pit, begins where the subclavian ends, at the outer border of the first rib, passes downward and outward through the axillary space to the lower margin of the teres major muscle, and there terminates by becoming the brachial. Its branches are distributed to the walls of the chest, the mammary gland, the arm-pit, the shoulder, and the upper part of the arm. At its beginning the artery is deeply situated; but its lower portion is near the surface, and can be felt a third of the distance from the

front to the back of the axilla, at the inner border of the coraco-brachialis. The artery is crossed by the pectoralis minor muscle, which divides it into three portions. The first portion is between the outer border of the first rib and the inner margin of the pectoralis minor, and is about an inch long; the second portion is behind the pectoralis minor, and measures a little more than an inch; and the third portion is between the outer border of the pectoralis minor and the lower border of the axillary space, and is three inches in length. The relations of these three portions differ.

Relations.—First Portion.—*In front* are the pectoralis major, the costo-coracoid membrane, the external anterior thoracic nerve, the cephalic and acromio-thoracic veins. *Mesially* and somewhat to the front is the axillary vein. *Behind* are the first intercostal space, the second rib, the serratus magnus, the internal anterior thoracic and posterior thoracic nerves. *Externally* is the brachial plexus.

Second Portion (Fig. 486).—*In front* are the pectoralis major and minor. *Mesially* are the inner cord of the brachial plexus, the axillary vein, and the internal anterior thoracic nerve between the artery and vein. *Behind* are the pos-

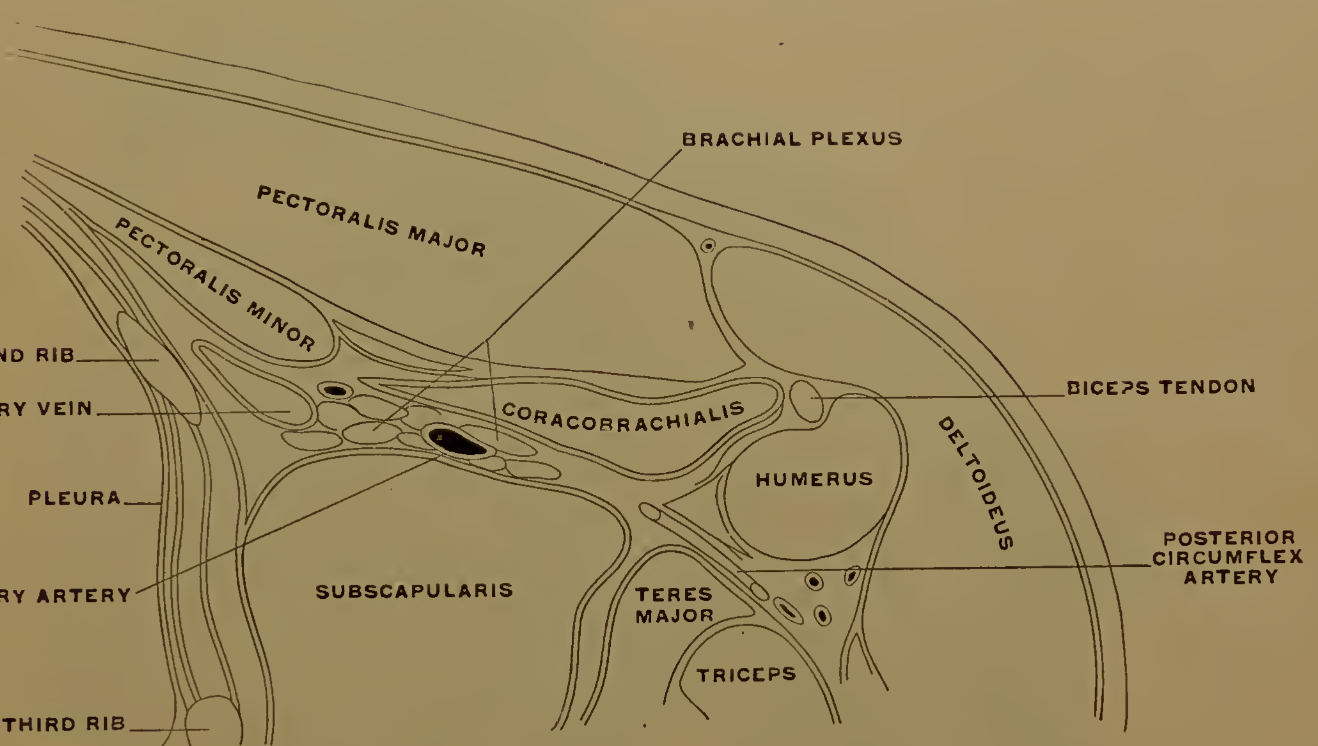


Fig. 486.—Horizontal section below the head of the humerus, showing the relations of the axillary structures at this plane. (Braune.)

terior cord of the brachial plexus and the subscapularis. *Externally* is the outer cord of the brachial plexus.

Third Portion.—*In front* are the pectoralis major in the upper half of this portion, the skin and fasciæ in the lower, the inner head of the median nerve, the internal cutaneous nerve, and the outer brachial vena comes. *Mesially* are the ulnar nerve, the axillary vein, and the small internal cutaneous nerve in the order named, and at the lower part the brachial venæ comites. *Behind* are the musculo-spiral and circumflex nerves, the subscapularis, latissimus, and teres major. *Externally* are the median and musculo-cutaneous nerves, and the coraco-brachialis.

The **Branches** of the axillary artery are usually seven in number, two, the superior thoracic and acromio-thoracic, from the first portion; two, the long thoracic and alar thoracic, from the second; and three, the subscapular and the posterior and anterior circumflex, from the third portion. There is a very free anastomosis between these branches, and between them and other arteries in the region. The *superior thoracic* arises from the first portion of the axillary, and passes downward and forward to supply the pectoralis major and minor muscles. The *acromio-thoracic* artery arises from the first portion of the axillary; it breaks up into three sets of branches: one passes outward to the acromion and deltoid,

the second passes down the arm with the cephalic vein, and is distributed to the pectoralis major and deltoid, and the third supplies the pectoral and the serratus magnus muscles. The *long thoracic* artery arises from the second portion of the axillary, passes downward along the outer border of the pectoralis minor, and sends branches to the serratus magnus, the pectorales major and minor, and the mammary gland. The *alar thoracic*, arising from the second portion, consists either of a single branch or a number of small branches, distributed to the lymphatic nodes, the fat and the areolar tissue of the axilla. The *subscapular* artery is the largest branch of the axillary. It starts from the third portion, passes downward on the subscapularis muscle, and, at about the centre of the axillary border of the scapula, it gives off a large branch, the *dorsal scapular* artery, which winds into the infraspinatus muscle, and anastomoses with the suprascapular and posterior scapular arteries. The rest of the artery passes

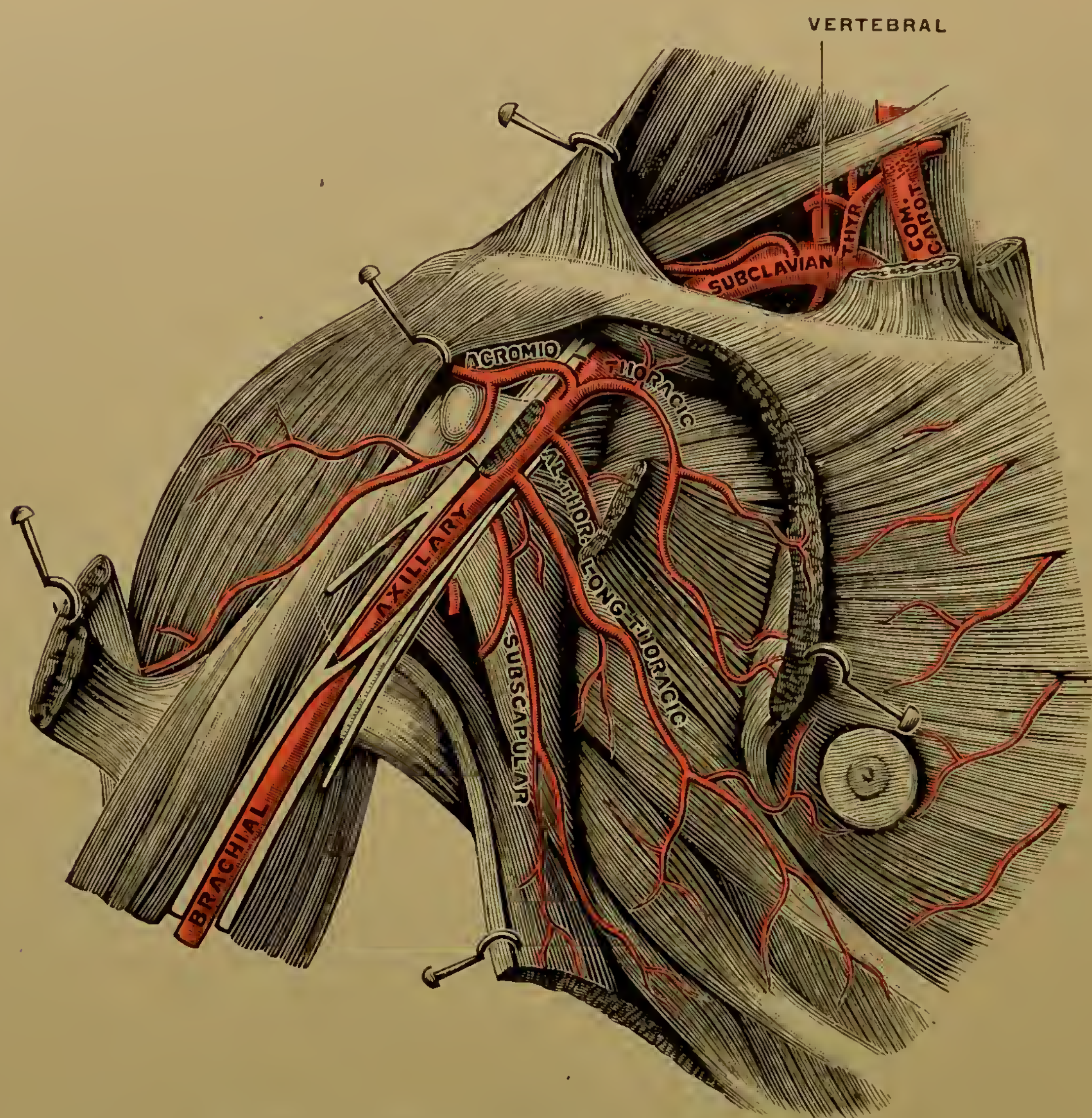


FIG. 467.—Axillary and subclavian arteries. (Testut.)

downward on the chest wall, and is distributed to the muscles in this region—the subscapularis, the serratus magnus, the latissimus, and the teres major. The *posterior circumflex* is much larger than the anterior. It arises from the third portion of the axillary, and winds backward between the teres muscles, the humerus and the long head of the triceps, and around the neck of the humerus. It accompanies the circumflex nerve, and supplies the deltoid and other structures about the shoulder, and the joint itself. The *anterior circumflex* arises from the outer side of the third portion of the axillary artery. It passes forward in front of the humerus, is covered by the coraco-brachialis and the tendons of the biceps, sends branches to the shoulder-joint and deltoid, and anastomoses with the posterior circumflex.

Variations.—The axillary sometimes gives off one of the arteries of the forearm. This is usually the radial, but is sometimes the ulnar, and, occasionally,

the interosseous. Very often the usual number of branches from the axillary is diminished by the origin of two or more from a common trunk. The third portion of the axillary is sometimes crossed by a muscular slip extending from the latissimus to some muscle or fascia in or near the front of the axilla.

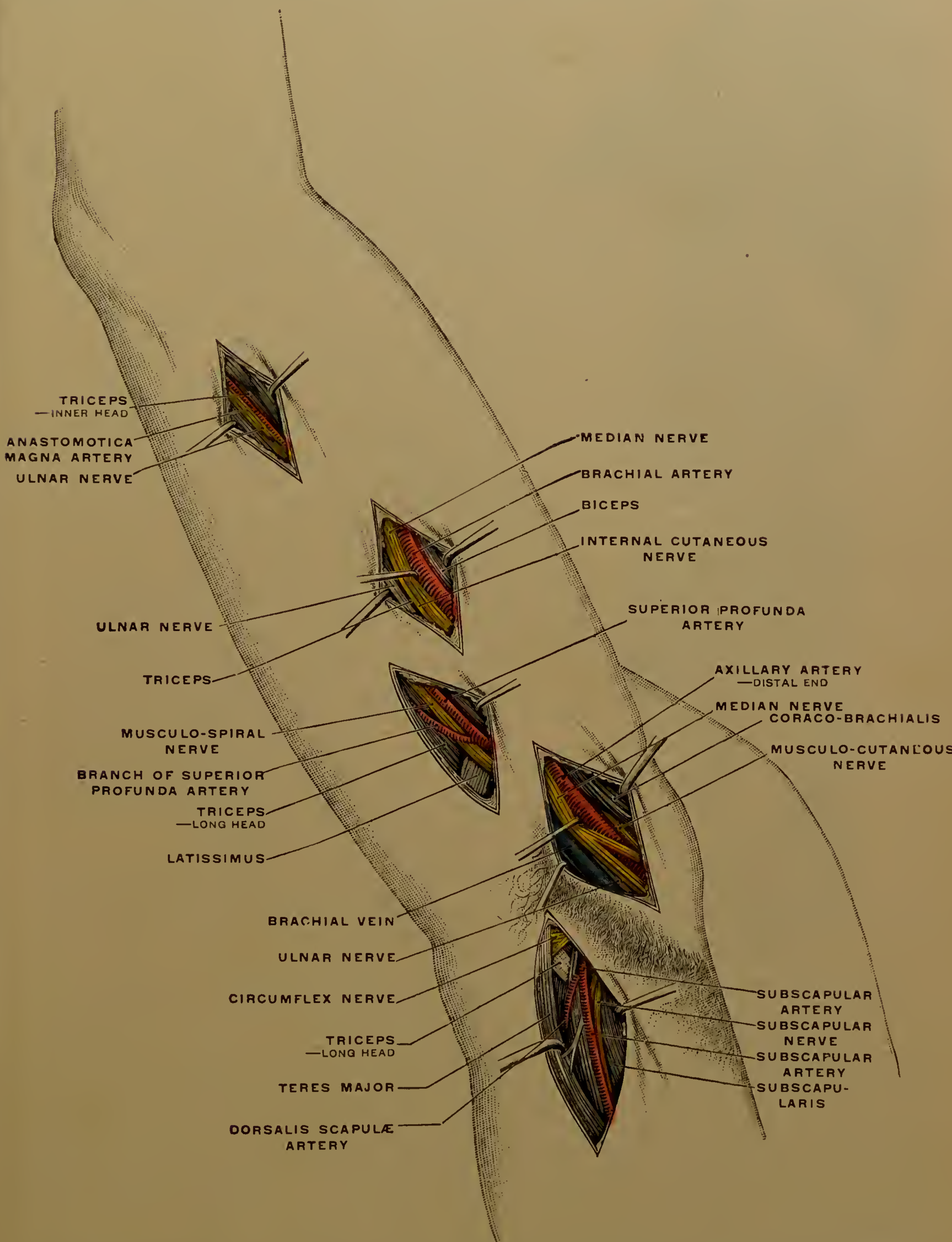


FIG. 488.—Surgical relations of the axillary, subscapular, brachial, superior profunda, and anastomotica magna arteries. The right arm is represented as raised almost to the perpendicular. (Kocher.)

THE BRACHIAL ARTERY.

The *brachial artery* (Fig. 489), sometimes called the *humeral*, is the great trunk of the arm. It extends from the lower border of the teres major to half an inch

below the bend of the elbow, following the direction of the inner border of the coraco-brachialis and biceps, thus being at first in the mesial part of the arm, gradually curving forward, and ending in the middle of the front of the limb just below the plane of the head of the radius.

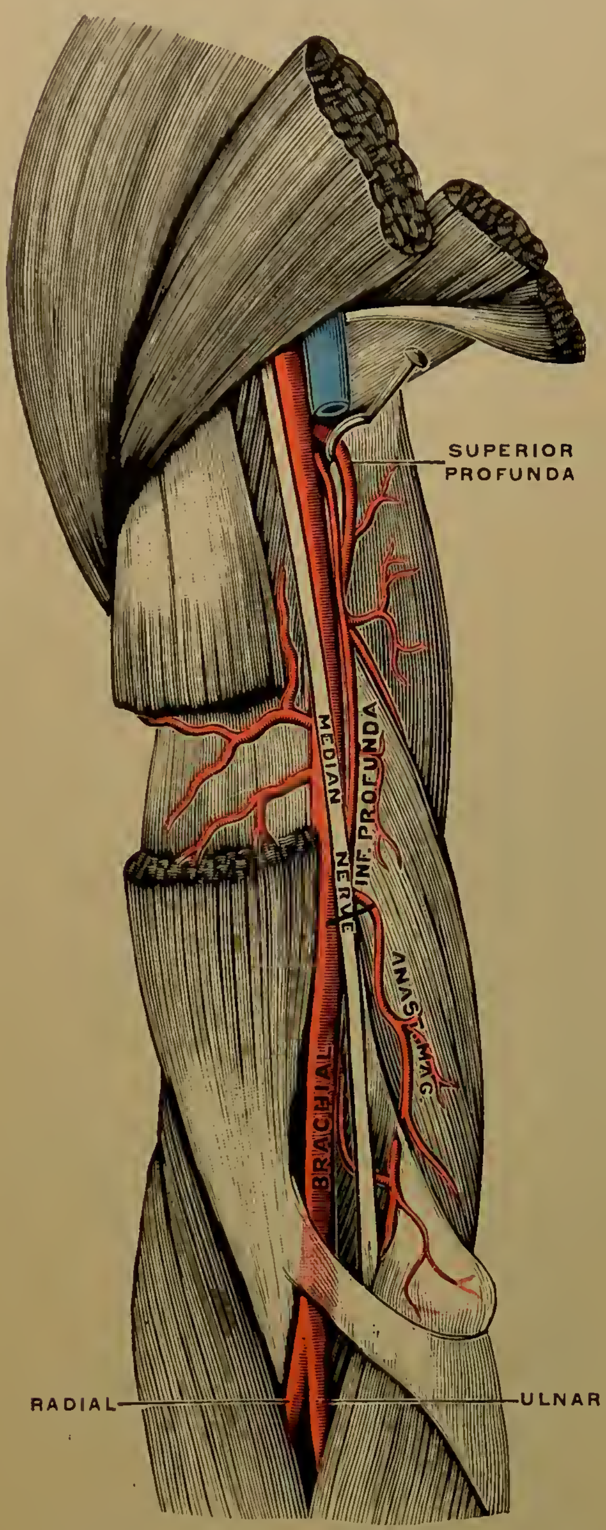


FIG. 489.—Brachial artery. (Testut.)

Relations (Figs. 490–492).—*In front*, in the greater part of its course, the coraco-brachialis and biceps in turn overlap the artery, the median nerve crosses the middle third; in the lowest part are the secondary tendon of insertion of the biceps, separating the artery from the median basilic vein, with the brachio-radialis and pronator teres overlapping. *Behind*, successively from above downward are the long and internal heads of the triceps, the coraco-brachialis, and the brachialis. The musculo-spiral nerve and superior profunda artery lie between the brachial and the long head of the triceps. *At the inner side* are the internal vena comes, and the basilic vein, the latter separated from the artery in its lower part by the fascia; in the upper third the internal cutaneous and ulnar nerves; in the lower part the median nerve and inferior profunda artery. *At the outer side*, the external companion vein, the coraco-brachialis and biceps, and in the upper third the median nerve, which is thus seen to be successively at the outer side, in front, and at the inner side.

Variations.—High division of the brachial is frequently seen, and has been noted at all parts of its course. The vessel given off high up is usually the radial, sometimes the ulnar, rarely the interosseous.

Branches.—The brachial artery ends in two terminals, the ulnar and radial, and gives off in its course the superior profunda, inferior profunda, nutrient, anastomotica magna, and muscular. The *superior profunda*, the largest branch, arises very near the beginning of the brachial from its dorso-mesial aspect, passes backward and around the humerus in the musculo-spiral groove with the musculo-spiral nerve, which it accompanies to the front of the external condyle, and anastomoses with the radial recurrent. Its principal offset is the articular branch, which supplies the elbow-joint, and inosculates behind the external condyle with posterior recurrent branches from the interosseous and ulnar, with the inferior profunda and the anastomotica magna. It gives branches to the muscles among which it runs, and the largest and highest of these anastomoses with the posterior circumflex. It may give a nutrient branch to the humerus. The *inferior profunda*, a smaller vessel, springs from the mesial side of the brachial below the superior, and runs to the back of the inner condyle in company with the ulnar nerve. It inosculates with the posterior ulnar recurrent and the anastomotica magna. The *nutrient* (medullary) enters the humerus through the nutrient foramen. The *anastomotica magna*, called "the great anastomotic," from the extent to which it takes part in the formation of the arterial network around the elbow-joint, arises about two inches above the bifurcation of the brachial from its mesial

aspect, goes inward above the internal condyle and around the back of the humerus, and forms an arch above the olecranon fossa, inosculating with the articular branch of the superior profunda and the interosseous recurrent, and also with the anterior and posterior ulnar recurrent. The *muscular* branches are variable in number, and supply adjacent muscles.

The Ulnar Artery.

The *ulnar artery* (Figs. 494–496), one of the terminal branches of the brachial, passes from its origin inward and downward in the ventral portion of the forearm. It is deeply situated in the upper part of its course, but becomes superficial in the lower half of the forearm, where it runs upon the flexor profundus digitorum and between the flexor carpi ulnaris and flexor sublimis. It passes over the anterior annular ligament into the palm, which it crosses in a gentle

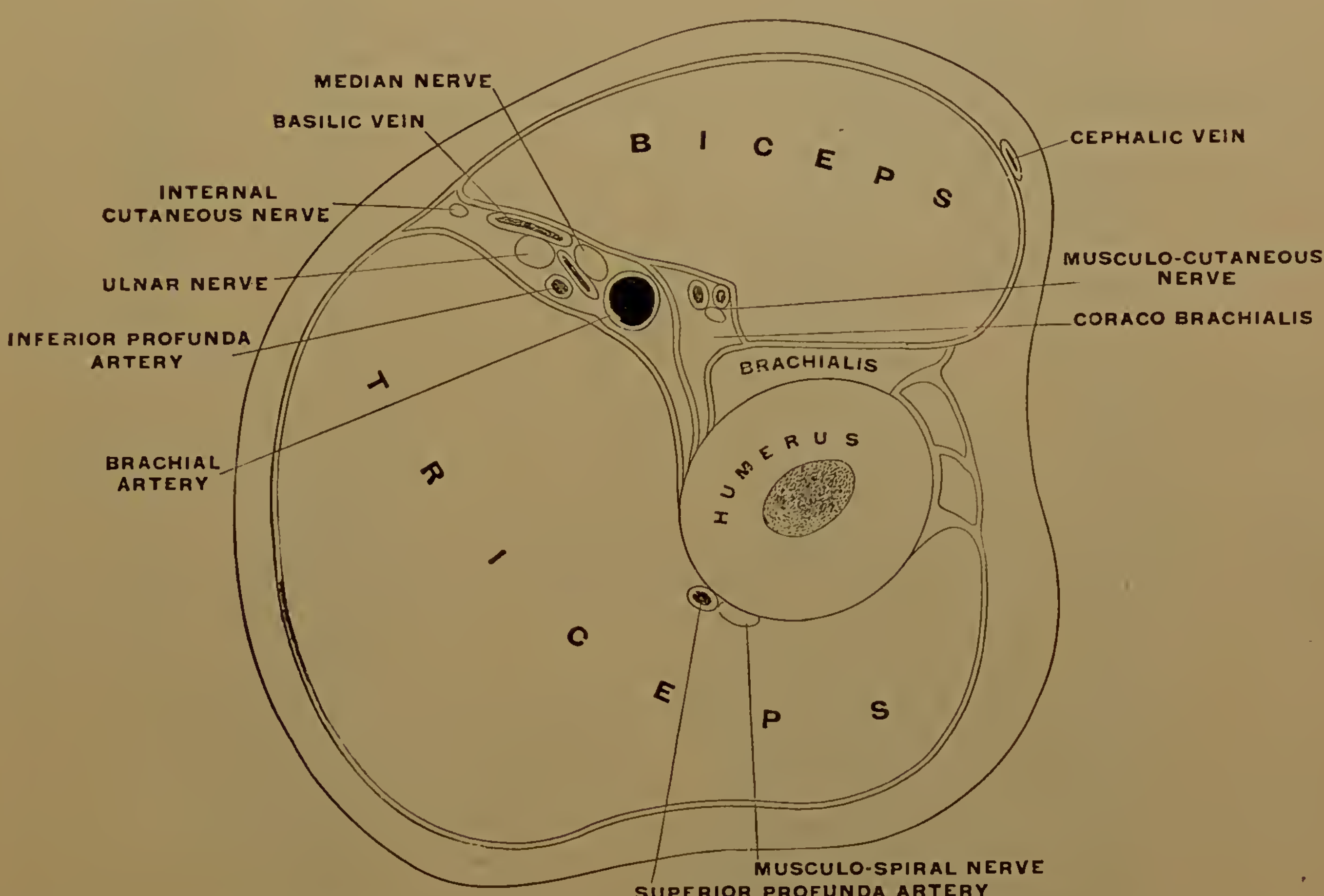


Fig. 490.—Horizontal section through the middle of the right arm—upper surface of the lower segment. (Braune.)

curve, and becomes the chief factor in the formation of the superficial palmar arch.

Relations.—In the Forearm (Figs. 498–500).—*In front* in the upper half are the superficial flexors; in the lower half, the fasciæ. *Behind* are the brachialis above, and the flexor profundus below. *At the inner side* are a vena comes all the way; for the lower two-thirds the ulnar nerve and the flexor carpi ulnaris. *At the outer side* are a vena comes throughout, the flexor sublimis for the most of its course, and the pronator teres above.

In the Wrist.—*In front* is the tendon of insertion of the flexor carpi ulnaris. *Behind* is the annular ligament. *At the inner side* are the pisiform bone and the ulnar nerve. *At the outer side* is the unciform. Venæ comites accompany the artery.

In the Hand below the Wrist.—The artery runs across nearly on a line with the lower border of the forcibly extended thumb. *In front* are the palmar fascia and palmaris brevis. *Behind* are the flexor tendons, the short muscles of the little finger, and branches of the median and ulnar nerves. Venæ comites accompany the vessel.

Variations.—The ulnar may arise from the brachial in the arm, or may come from the axillary. It is sometimes superficially situated in its entire course.

Branches.—These are considered in three groups: those in the forearm, those in the wrist, and those in the hand below the wrist. In the first group are the

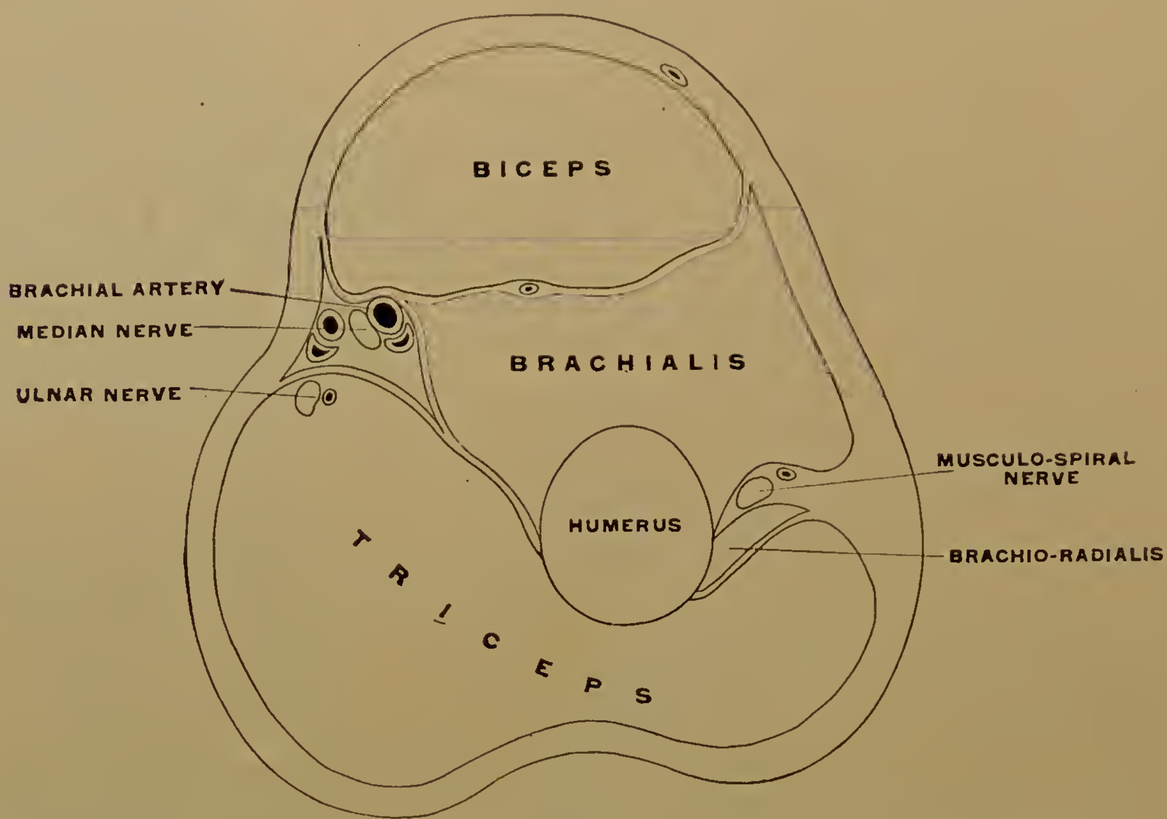


FIG. 491.—Horizontal section through the middle of the lower third of the arm—upper surface of the lower segment. (Braune.)

anterior and posterior ulnar recurrent, the interosseous, and the muscular; in the second, the anterior and posterior ulnar carpal; in the third, the deep palmar, and the digital. The artery beyond the point of origin of the deep palmar

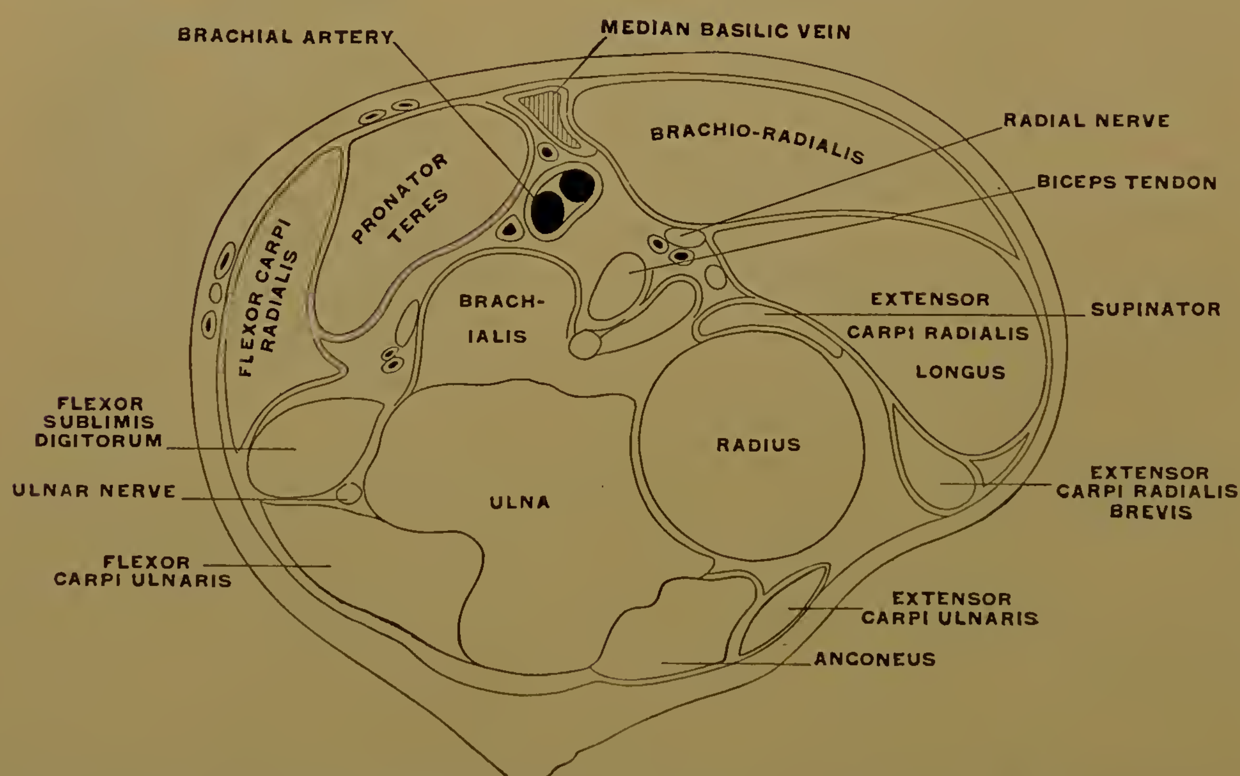


FIG. 492.—Horizontal section just below the bend of the elbow, showing the brachial artery at its bifurcation. (Braune.)

is sometimes considered as one of two terminal branches, and is then called the superficial palmar.

BRANCHES IN THE FOREARM.—The *anterior ulnar recurrent*, the highest branch, runs upward and inward to the front of the internal condyle. It some-

times arises from a trunk common to it and the posterior recurrent. The *posterior ulnar recurrent*, larger than the preceding, winds backward and inward beneath the flexor sublimis, behind the internal condyle, lying near the ulnar nerve. It supplies the joint and the adjacent muscles, and inosculates with the inferior profunda, anastomotica magna, and interosseous recurrent arteries. The *interosseous*, a very short vessel, arises from the dorso-external aspect of the ulnar below the radial tuberosity, passes backward and downward to the upper border of the interosseous membrane, and there divides into the anterior and posterior interosseous. The *anterior interosseous* passes down on the ventral surface of the interosseous membrane, giving branches to the deep muscles, *nutrient arteries* to the ulna and radius, an offset, the *median* artery, to the median nerve, and one which anastomoses with the anterior carpal arch. It runs behind the pronator quadratus, through the interosseous membrane to the back of the forearm, anastomoses with the posterior interosseous, and finally inosculates with the posterior carpal arch. The *posterior interosseous*, a larger vessel, courses back above the upper margin of the interosseous membrane, and then down the forearm between the superficial and deep muscles. It anastomoses with the anterior interosseous and the posterior carpal arch. High up it gives off the *posterior interosseous recurrent*, which runs to the elbow between the external condyle and the olecranon, and anastomoses with various arteries of the arm and forearm. The *muscular* branches supply the muscles contiguous to the artery.

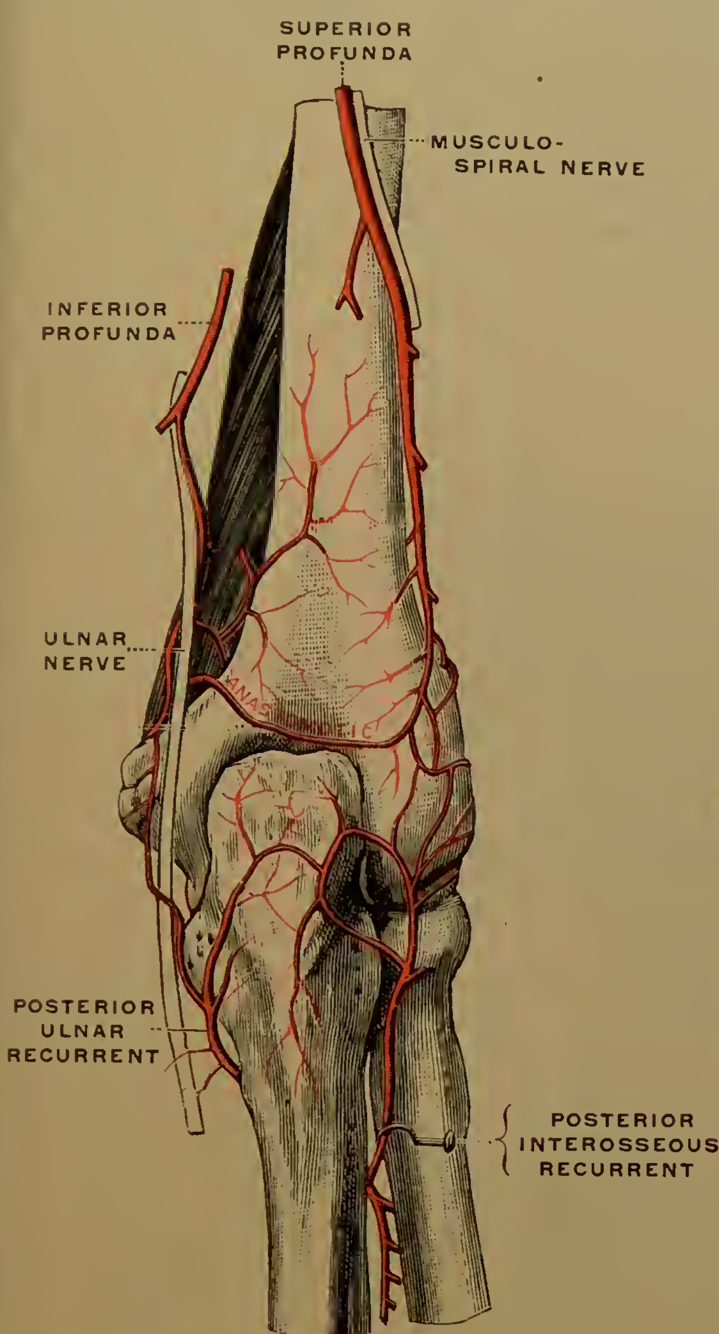


FIG. 493.—Anastomoses at the back of the elbow. (Testut.)

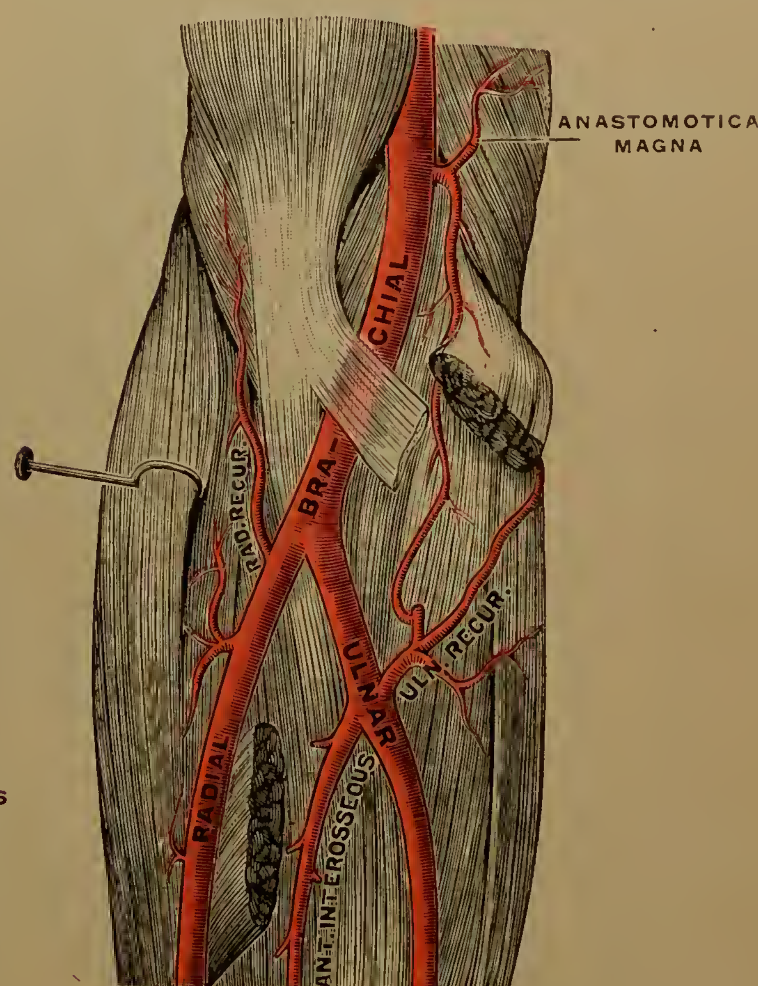


FIG. 494.—Arteries in the region of the bend of the elbow. (Testut.)

BRANCHES IN THE WRIST.—The *anterior ulnar carpal* runs across in the ventral part of the carpus, and inosculates with the anterior radial carpal, the two thus forming the anterior carpal arch. The *posterior ulnar carpal* passes outward beneath the extensor tendons and anastomoses with the posterior radial carpal, the union of the two forming the posterior carpal arch. The branches of this arch will be treated of in connection with the radial artery.

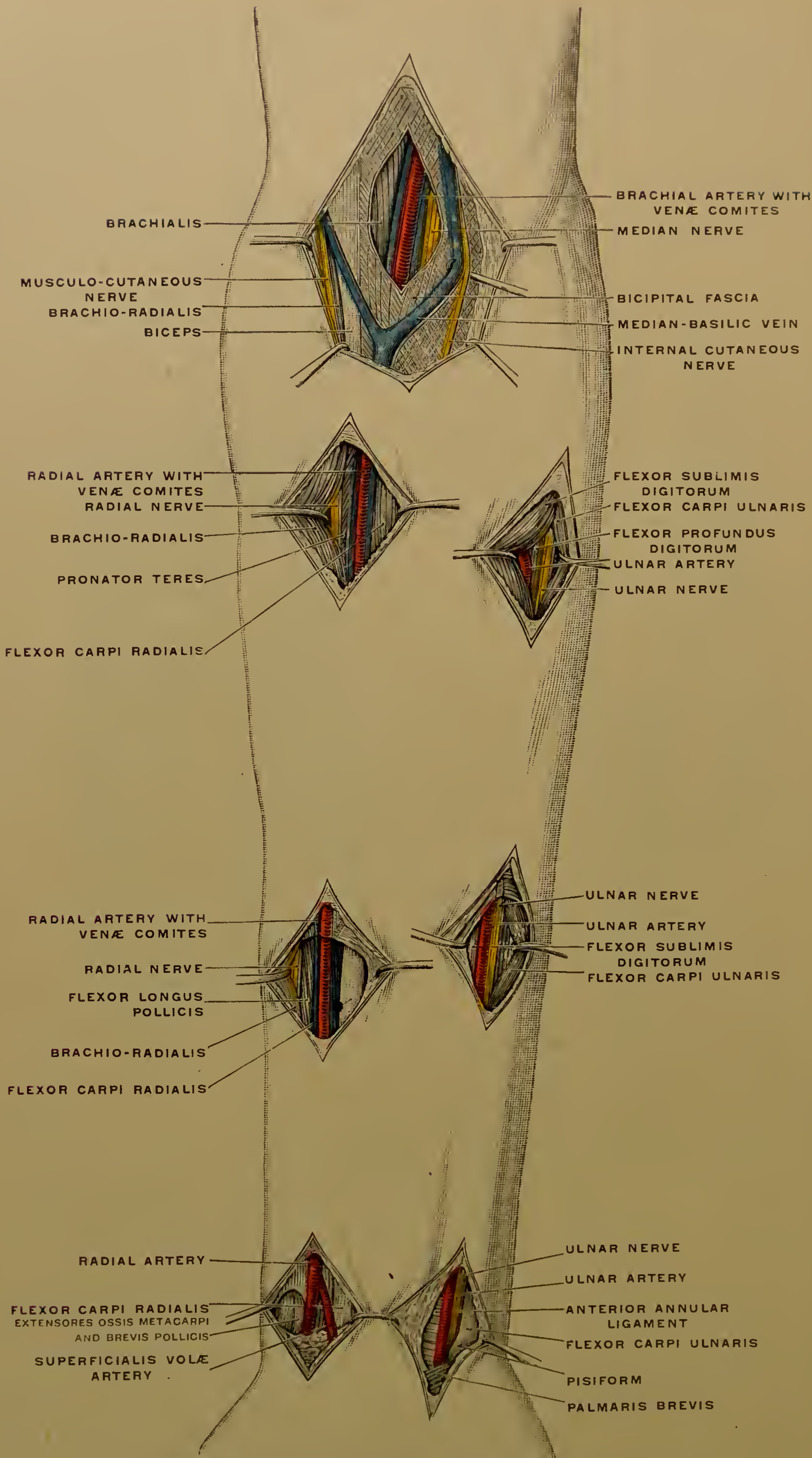


FIG. 495.—Surgical relations of the radial and ulnar arteries. (Kocher.)

Branches in the Hand below the Wrist.—The *deep palmar* (communicating), a large branch, enters the palm between the abductor and short flexor of the little finger, and by inosculation with the end of the radial contributes to the formation of the deep palmar arch. The four *digital* (Fig. 496) are named numerically, beginning at the ulnar side, are given off from the convexity of the superficial arch (superficial palmar), run down to the web of the fingers, where each except the first receives a palmar interosseous from the deep arch. The first goes to the ulnar side of the little finger; each of the others divides into two

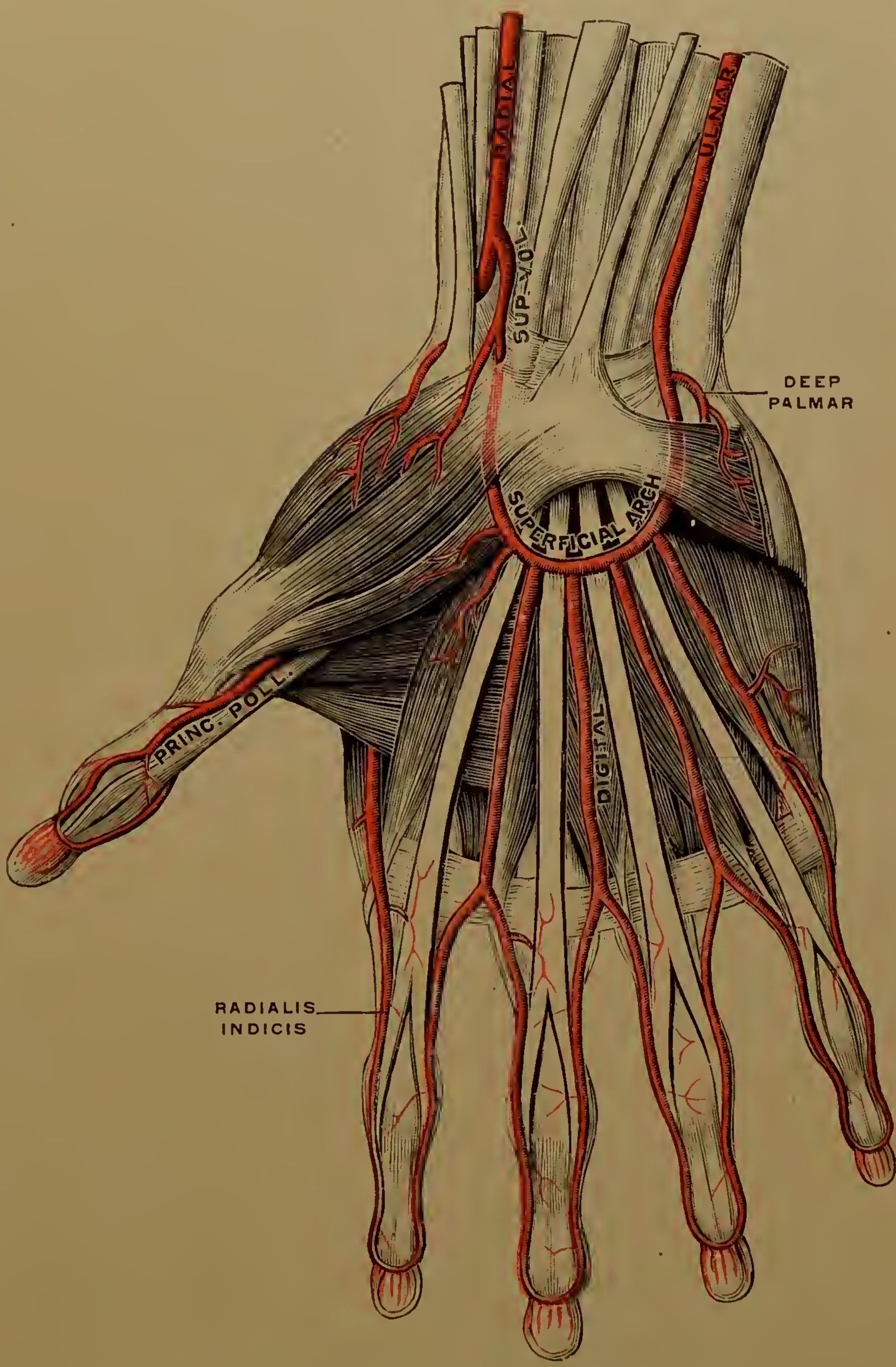


Fig. 496.—Superficial palmar arch and its branches. Of the digitals, only the third is labelled. (Testut.)

collateral digital branches, which pass to the contiguous sides of the little, ring, middle, and index fingers—the outer side of the index being fed by a branch of the radial.

The Radial Artery.

The *radial artery* (Figs. 494, 495, 497), one of the terminals of the brachial, is more in line with that vessel than is the ulnar, though somewhat smaller. It passes downward on the radial side of the forearm to the carpus, around the outer side of which it curves under cover of the extensors of the thumb to the

space between the heads of the abductor indicis, through this into the palm, crosses the proximal ends of the metacarpal bones, and ends by anastomosing with the deep branch of the ulnar, thus forming with the latter the deep palmar arch.

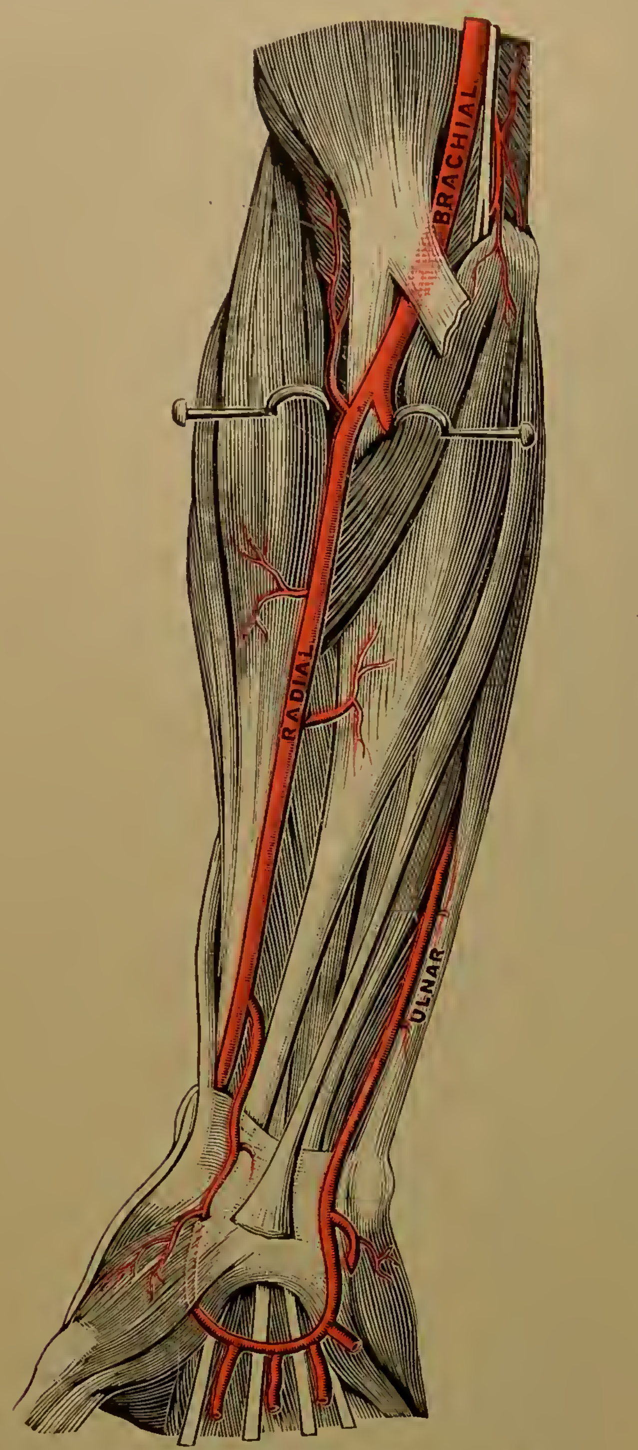


FIG. 497.—Arteries of the forearm—front view. (Testut.)

Relations.—IN THE FOREARM. (Figs. 498–500.)—*In front* in the upper part is the brachio-radialis; elsewhere are the fasciæ, some veins, and branches of the musculo-cutaneous nerve. *Behind* in succession are the biceps, supinator, pronator teres, flexor sublimis, flexor longus pollicis, pronator quadratus, and the radius. *At the outer side* are the brachio-radialis and a companion vein all the way, and the radial nerve in the middle third. *At the inner side* are a vena comes the entire course, the pronator teres in the upper third, and the flexor carpi radialis in the lower.

IN THE WRIST.—It is accompanied by venæ comites; is covered in different parts by the extensors of the thumb, branches of the radial nerve, and the skin and fascia; and runs in turn upon the external lateral ligament, the scaphoid, the trapezium, and the first metacarpal.

IN THE HAND BELOW THE WRIST.—Venæ comites and the deep branch of the ulnar nerve lie with the artery on (in front of) the proximal ends of the metacarpal bones and the interossei; and it is covered by the adductor pollicis, the long flexor tendons, the lumbricales, and the short flexors of the little finger and of its metacarpal bone. The deep arch is about an inch nearer the carpus than is the superficial.

Variations.—The radial frequently springs from the brachial in the arm, and may even arise from the axillary. Sometimes it is very small, its place being taken by branches from the ulnar and interosseous; and in this case it may be that no pulse can be found in the place where it is usually sought—just above the carpus, between the tendons of the brachio-radialis and the flexor carpi radialis.

Branches.—These are considered in three groups: those arising in the forearm, those given off in the wrist, and those in the hand below the wrist. In the first group are the radial recurrent, the muscular, the anterior radial carpal, and the superficial volar; in the second, the posterior radial carpal, the first dorsal interosseous, the dorsal artery of the thumb, and the dorsal artery of the index finger; in the third, the main artery of the thumb, the radial artery of the index finger, the palmar interosseous, the recurrent carpal, and the posterior communicating.

BRANCHES IN THE FOREARM.—The *radial recurrent*, the highest branch, starts from the outer side of the artery, and passes upward between the brachialis and brachio-radialis to the elbow-joint, and anastomoses with the superior profunda. *Muscular* branches supply muscles neighboring to the radial. The *anterior radial carpal* comes off near the lower border of the pronator quadratus.

runs across the radius, and anastomoses with the anterior ulnar carpal, forming with it the anterior carpal arch. The *superficial volar* (palmar) arises just above the wrist, passes between or over the muscles of the thenar eminence, and anastomoses with the ulnar in the palm, thus completing the superficial palmar arch.

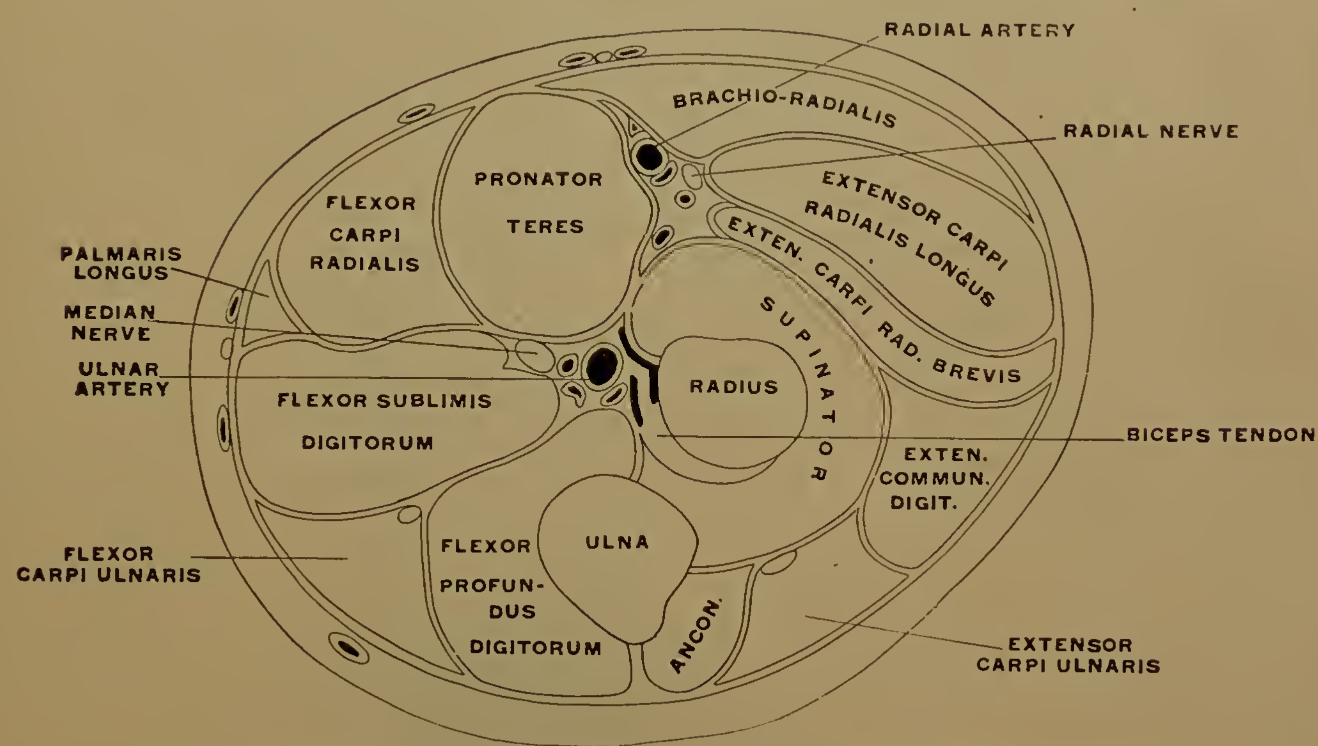


FIG. 498.—Horizontal section through the upper third of the right forearm—upper surface of the lower segment. In this and the two following figures the forearm is semipronated. (Braune.)

BRANCHES IN THE WRIST.—The *posterior radial carpal* crosses the dorsum of the carpus and anastomoses with the posterior ulnar carpal, thus being formed the posterior carpal arch (Fig. 502). From this are given off the *second* and *third dorsal interosseous*, which run down to the web of the fingers, where each divides

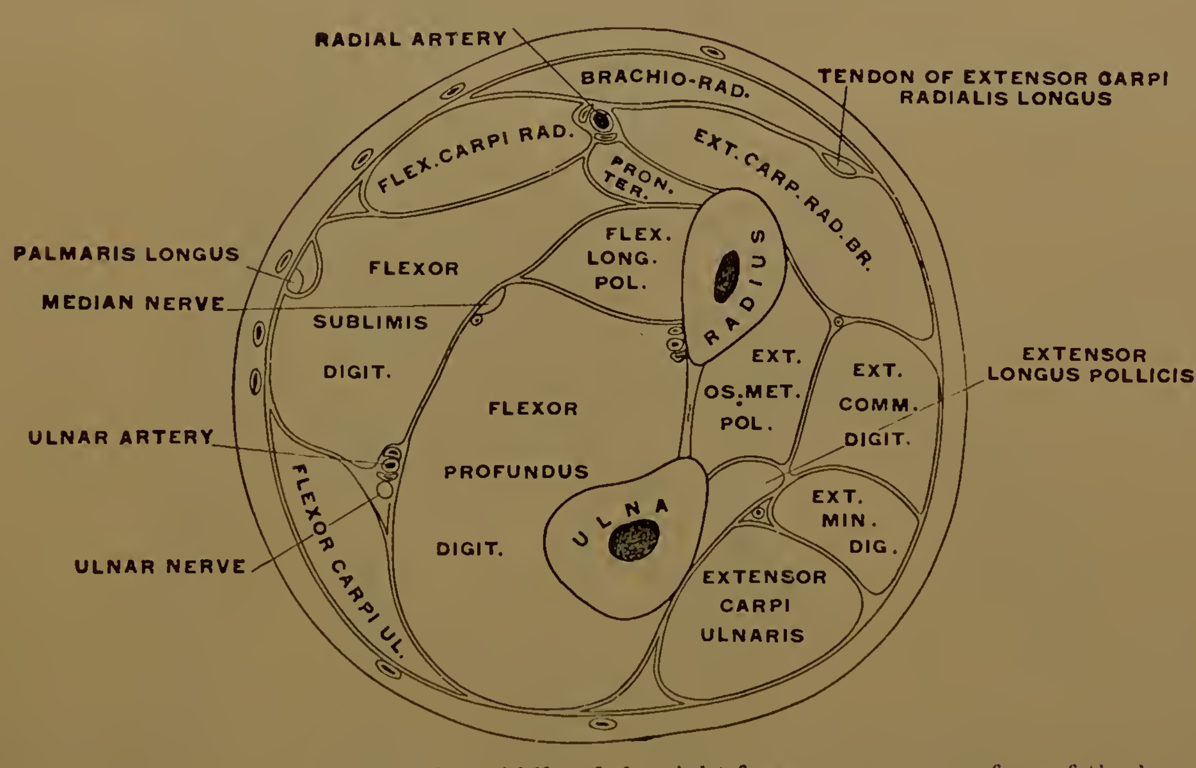


FIG. 499.—Horizontal section through the middle of the right forearm—upper surface of the lower segment. (Braune.)

into two branches (*dorsal digital*) supplying the contiguous sides of the medius and annularis, and annularis and minimus on the dorsal aspect. The arch has anastomoses with the posterior communicating branches of the deep palmar arch, and the anterior communicating of the digital branches of the ulnar. The *first dorsal interosseous*, sometimes called *metacarpal*, passes down in the second interosseous space, and is distributed through dorsal digital branches to the adjacent sides of the index and medius. It sometimes arises with the posterior radial

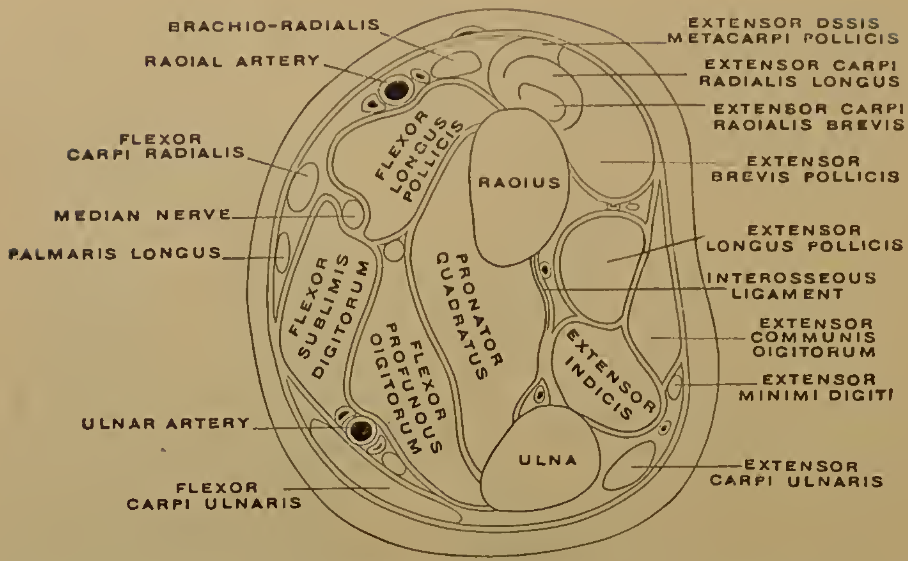


FIG. 500.—Horizontal section through the lower third of the right forearm. (Braune.)

carpal by a common trunk. It resembles the other dorsal interosseous arteries

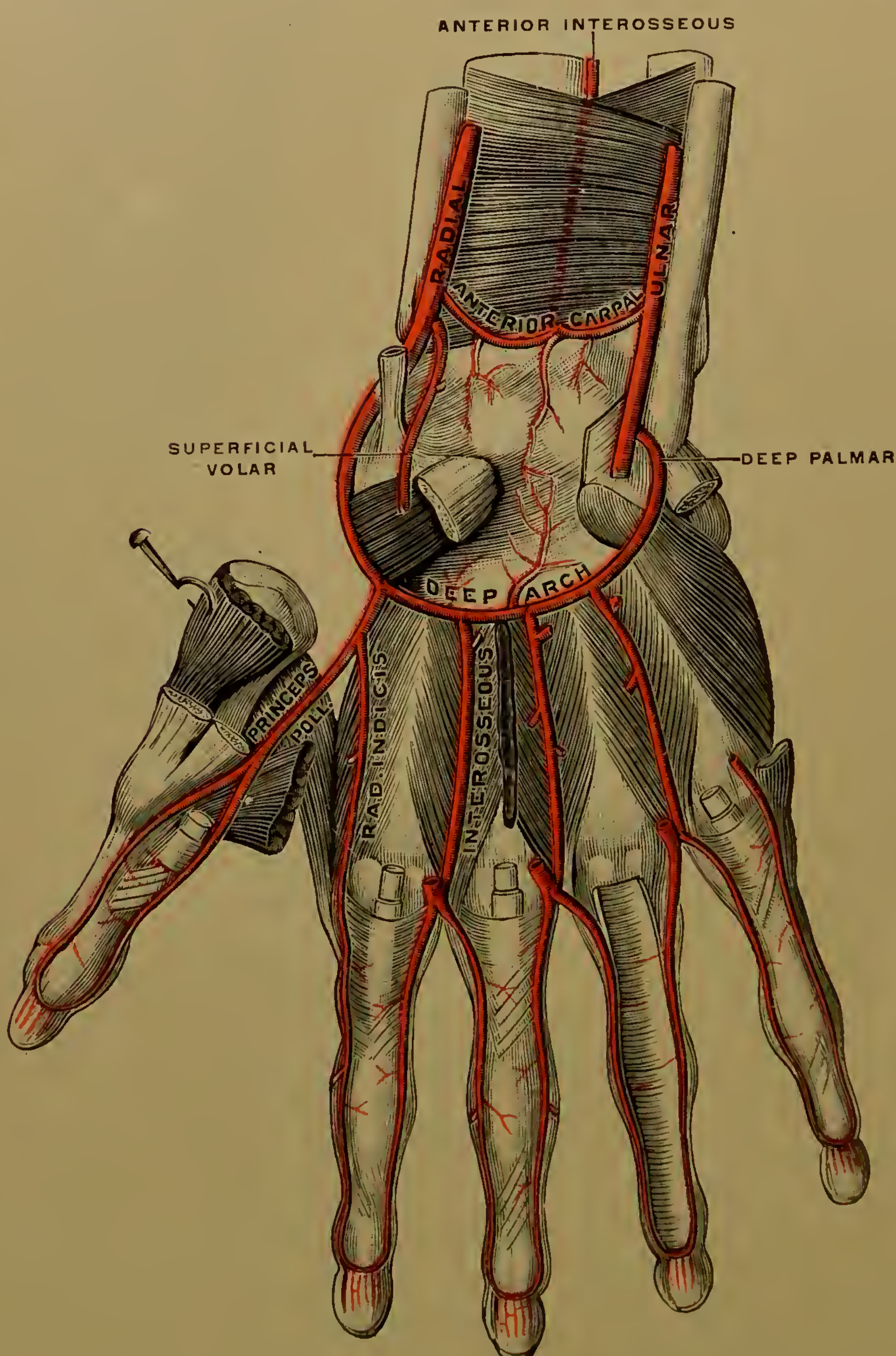


FIG. 501.—The deep palmar arch and its branches. The first metacarpal bone has been disarticulated to show the course of the radial around the wrist. Of the palmar interosseous, only the first is labelled. (Testut.)

in distribution and anastomoses. The *dorsal artery of the thumb* (dorsalis pollicis) arises either separately or from a trunk common to it and the dorsal artery of the

index, just before the radial pierces the abductor pollicis. It sends a branch down each side of the back of the thumb. The *dorsal artery of the index finger* (dorsalis indicis) is given off near the last described, or by a common trunk with it, and passes down on the back of the radial side of the forefinger.

Branches in the Hand below the Wrist (Fig. 501).—The *principal artery of the thumb* (princeps pollicis) runs along the ulnar side of the first metacarpal bone, and sends a branch down each side of the thumb on its palmar

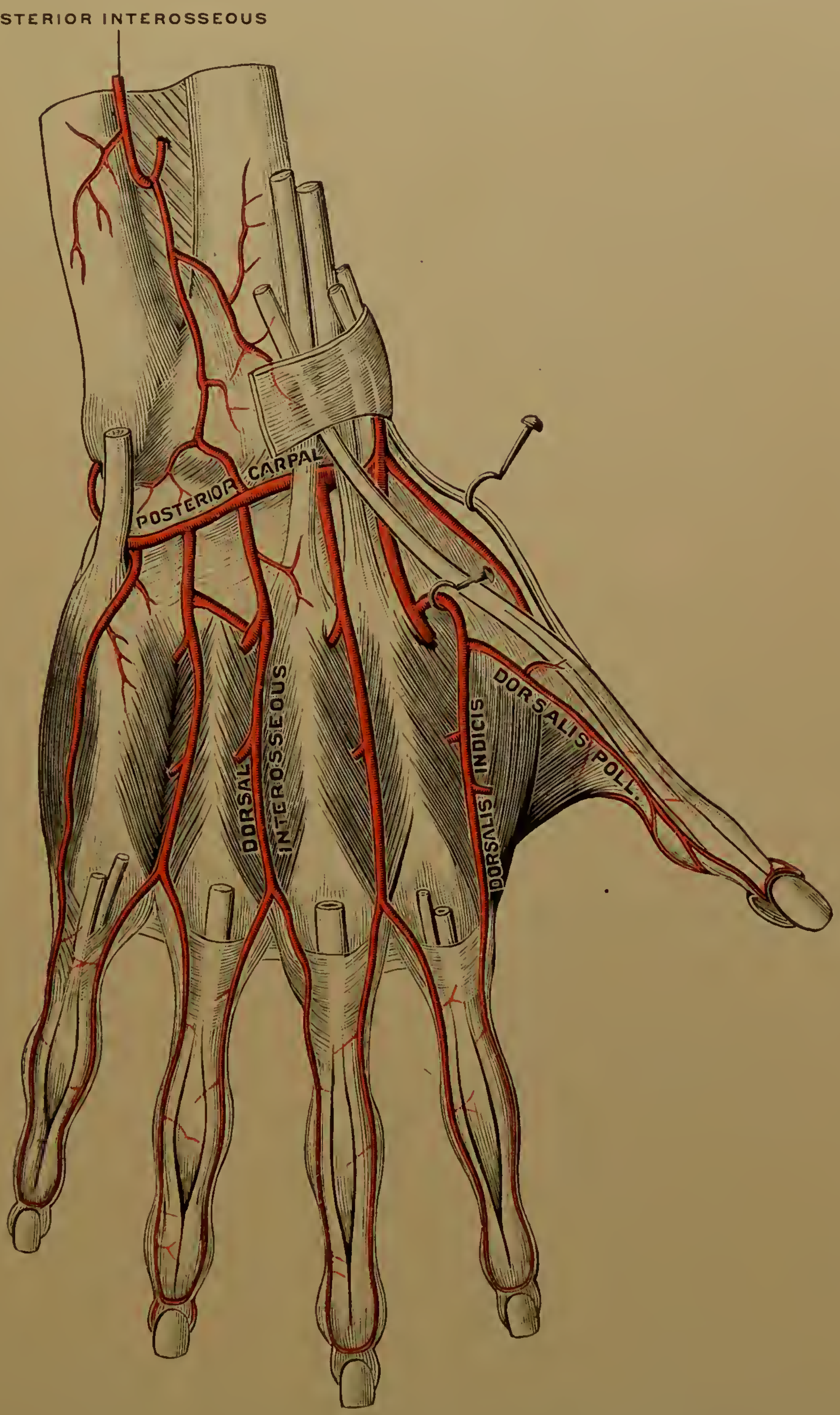


Fig. 502.—Arteries of the dorsum of the hand. Only the second of the dorsal interosseous is labelled. (Testut.)

aspect. The *radial artery of the index* (radialis indicis) arises close to the last described, or from a common trunk with it, and descends on the radial side of the forefinger. The *palmar interosseous*, three in number, arise from the deep arch, pass down in the second, third, and fourth metacarpal spaces, and inosculate with the digital branches from the ulnar at the web of the fingers. The *recurrent carpal*, of small size, and few in number, run upward, and inosculate with the anterior carpal arch. The three *posterior communicating* (perforating) run back-

ward through the upper part of the second, third, and fourth interosseous spaces, and anastomose with the dorsal interosseous arteries.

The derivation of the blood-supply of the digits of the hand is shown in the accompanying diagram (Fig. 503).

Summary (Fig. 503).—Four arches are formed by anastomoses between the radial and ulnar arteries—the posterior carpal, the anterior carpal, the deep palmar, and the superficial palmar.

The *posterior carpal arch* (Fig. 502), formed by the inosculation of the posterior carpal branches of the radial and the ulnar, crosses the dorsum of the wrist, and receives from above branches from the posterior and anterior interosseous arteries of the forearm. It gives off dorsal interosseous branches, which run

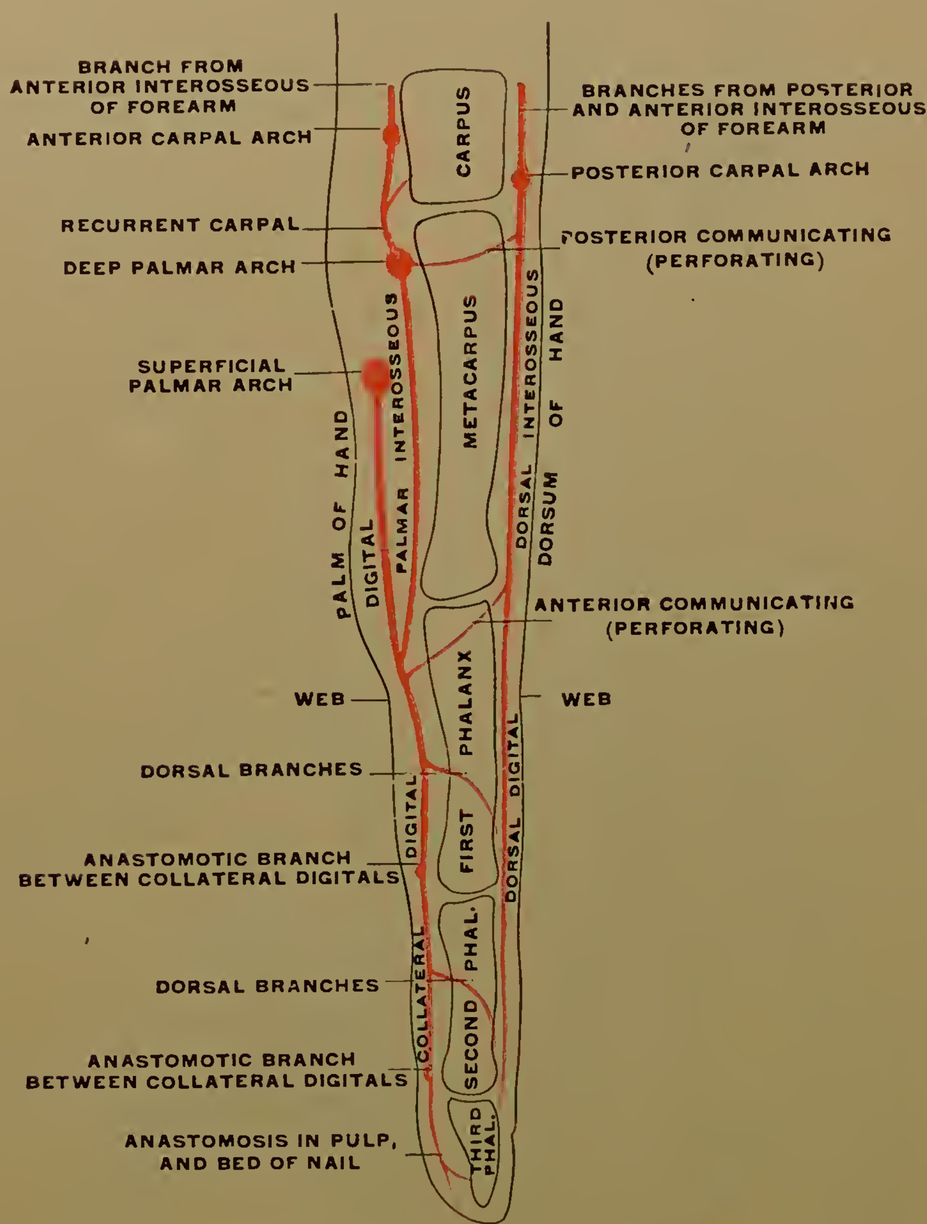


FIG. 503.—Diagram to show the arterial supply of the digits. The middle finger is shown in longitudinal section. (F. H. G.)

between metacarpal bones. Each of these divides at the web of the fingers into two dorsal digital arteries, which course at the sides of the posterior aspect of the adjacent fingers. The dorsal interosseous also send forward anterior communicating (perforating) branches, which join the digital and palmar interosseous where these unite. The posterior carpal arch is also connected with the deep palmar through the dorsal interosseous by means of the posterior communicating (perforating) arteries.

The *anterior carpal arch* (Fig. 501), formed by the anastomosis of the anterior carpal branches of the ulnar and radial, lies in the ventral part of the wrist, and receives from above branches from the anterior interosseous artery of the forearm, and from below recurrent carpal branches from the deep palmar arch.

The *deep palmar arch* (Fig. 501), made chiefly by the radial artery, but finished by the deep branch of the ulnar, rests on the proximal ends of the metacarpal bones. It gives offsets in three directions: recurrent carpal upward to the anterior carpal arch and the carpal articulations; posterior communicating (perforating) backward to the dorsal interosseous; and palmar interosseous downward to the junction of the digital and anterior communicating (perforating) in the web of the fingers.

The *superficial palmar arch* (Fig. 496), formed mainly by the ulnar artery and completed by the superficial volar, is situated between the palmar fascia and the flexor tendons, and is further from the carpus than the deep arch. It sends digital branches downward to the web of the fingers, where they are joined by the palmar interosseous from the deep arch, and the anterior communicating (perforating) from the dorsal interosseous. The artery thus formed immediately divides into two branches, which run to the adjacent sides of contiguous fingers on their palmar aspect as collateral digital arteries. Each of these last sends a dorsal branch backward to the hind surface near the middle of the first phalanx, and another near the middle of second phalanx. Proximal to each interphalangeal joint an anastomotic branch connects the two collaterals of each finger across the palmar aspect. The collaterals terminate in the pulp of the finger and the bed of the nail.

The foregoing description of the arterial supply of the digits does not precisely apply to the thumb and index finger; but their arteries are homologous to these, and their differences have been sufficiently set forth already.

THE BRANCHES OF THE THORACIC AORTA.

The branches of the thoracic aorta (Fig. 504) are the pericardial, the bronchial, the œsophageal, the posterior mediastinal, the intercostal, and the subcostal.

The *pericardial* are vessels of small size which supply the pericardium. The *bronchial* arteries supply the parenchyma of the lung with arterial blood. One is given off on the right side, and the left has two. The right one often is a branch of the first aortic intercostal. In addition to supplying the lungs the bronchial arteries send branches to the bronchial lymph-nodes and the œsophagus. The *œsophageal* arteries are small vessels, from three to five in number, supplying the œsophagus. The *posterior mediastinal* are small vessels, which pass backward to the thoracic vertebræ, and supply the lymph-nodes in the posterior mediastinum. The *intercostal* arteries arise from the posterior and lateral surfaces of the thoracic aorta and run outward to the intercostal spaces; they vary from nine to eleven in number. The upper two intercostal spaces are supplied, as already described, by the superior intercostal branch of the subclavian. Often, however, an aortic intercostal is sent to the second intercostal space. These vessels run in, or just below, the well-marked intercostal grooves on the inner surface and lower border of the ribs; and passing forward in the intercostal spaces to the anterior chest wall, they anastomose with the intercostal branches from the internal mammary and musculo-phrenic. In their course the intercostals give off posterior branches which pass backward through the intercostal spaces to reach the deep muscles of the back, which they supply. *Spinal* branches to the cord and its membranes and to the vertebral column are derived from these. The *collateral intercostal* branch runs from the main artery at a point opposite the angle of the rib to the upper border of the rib below and runs forward in the intercostal space; this branch is much smaller than the intercostal itself. In their course the intercostal arteries and their branches send vessels to the thoracic walls, the parietal layer of the pleura, and the muscles covering the thorax; several branches of good size are sent to the mammary gland, usually from the third and fourth intercostal arteries. Several of the lower intercostals run forward between the abdominal muscles, and supply them. The *subcostal* runs under the last rib, sustaining a relation to it

comparable to that of an intercostal to its rib, and is distributed to the abdominal wall.

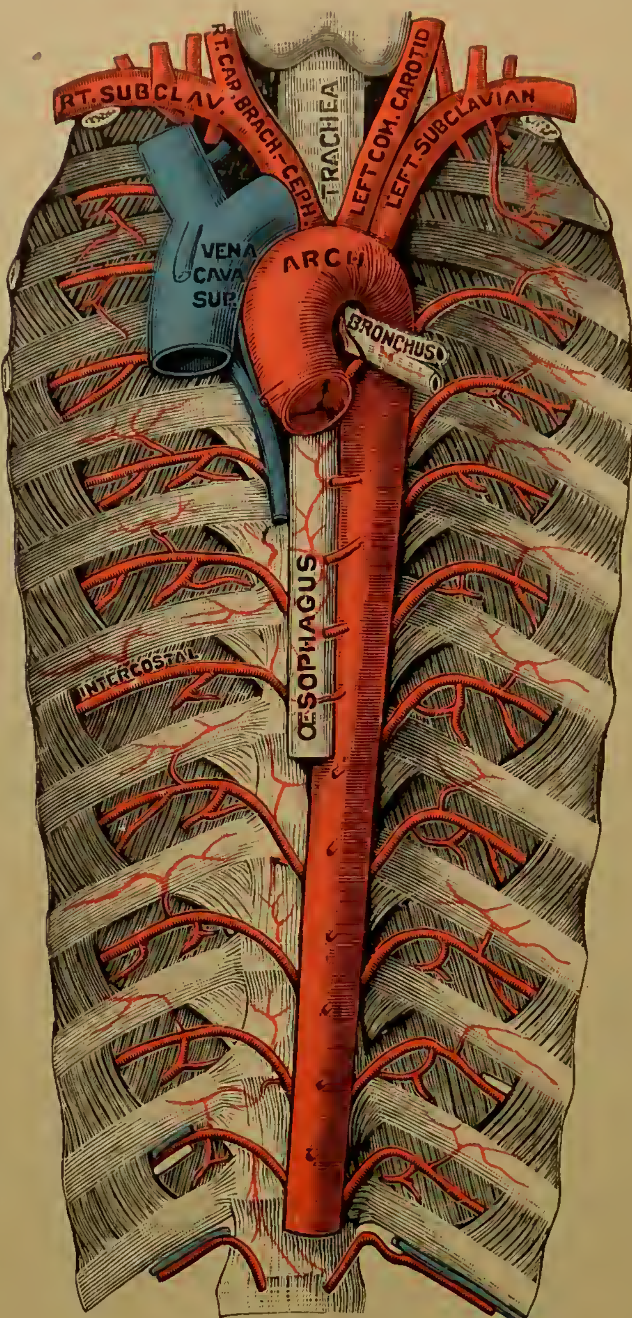


FIG. 504.—Thoracic aorta. (Testut.)

THE BRANCHES OF THE ABDOMINAL AORTA.

The branches of the abdominal aorta (Fig. 505) are conveniently divided for description into three groups—the visceral, the parietal, and the terminal. The *visceral group* includes the cœliac axis, the suprarenal, the superior mesenteric, the renal, the spermatic (or ovarian), and the inferior mesenteric; the *parietal group* consists of the phrenic, the lumbar, and the middle sacral; and the *terminal branches* are the right and left common iliac arteries.

The Cœliac Axis is given off from the abdominal aorta just below the aortic opening in the diaphragm; it is a stout, short trunk, about a half inch in length, and divides into the gastric, the hepatic, and the splenic arteries.

The **gastric artery** (Fig. 506) runs from the cœliac axis upward and to the left to the œsophageal orifice of the stomach; thence it passes from left to right along the small curvature of the stomach to the pyloric opening. In the first part of its course it gives off branches to the œsophagus; but most of its branches supply the stomach. The vessel is the smallest branch of the cœliac axis.

The **hepatic artery** (Fig. 506) passes transversely to the right to the right free edge of the small omentum; thence it passes upward in front of the foramen of Winslow to the transverse fissure of the liver, and divides into two branches to supply the right and left lobes of the liver. The relations of the hepatic artery,

the common bile-duct, and the portal vein are as follows: the vein behind, the duct in front at the right, the artery in front at the left.

The *branches* of the hepatic are the pyloric, the gastro-duodenal, the cystic, and the terminal. The *pyloric* branch passes to the pyloric end of the stomach, anastomosing with the gastric artery. The *gastro-duodenal* is a short, large vessel which passes downward and to the right behind the duodenum, and divides into the right gastro-epiploic and the superior pancreatico-duodenal. The right *gastro-*

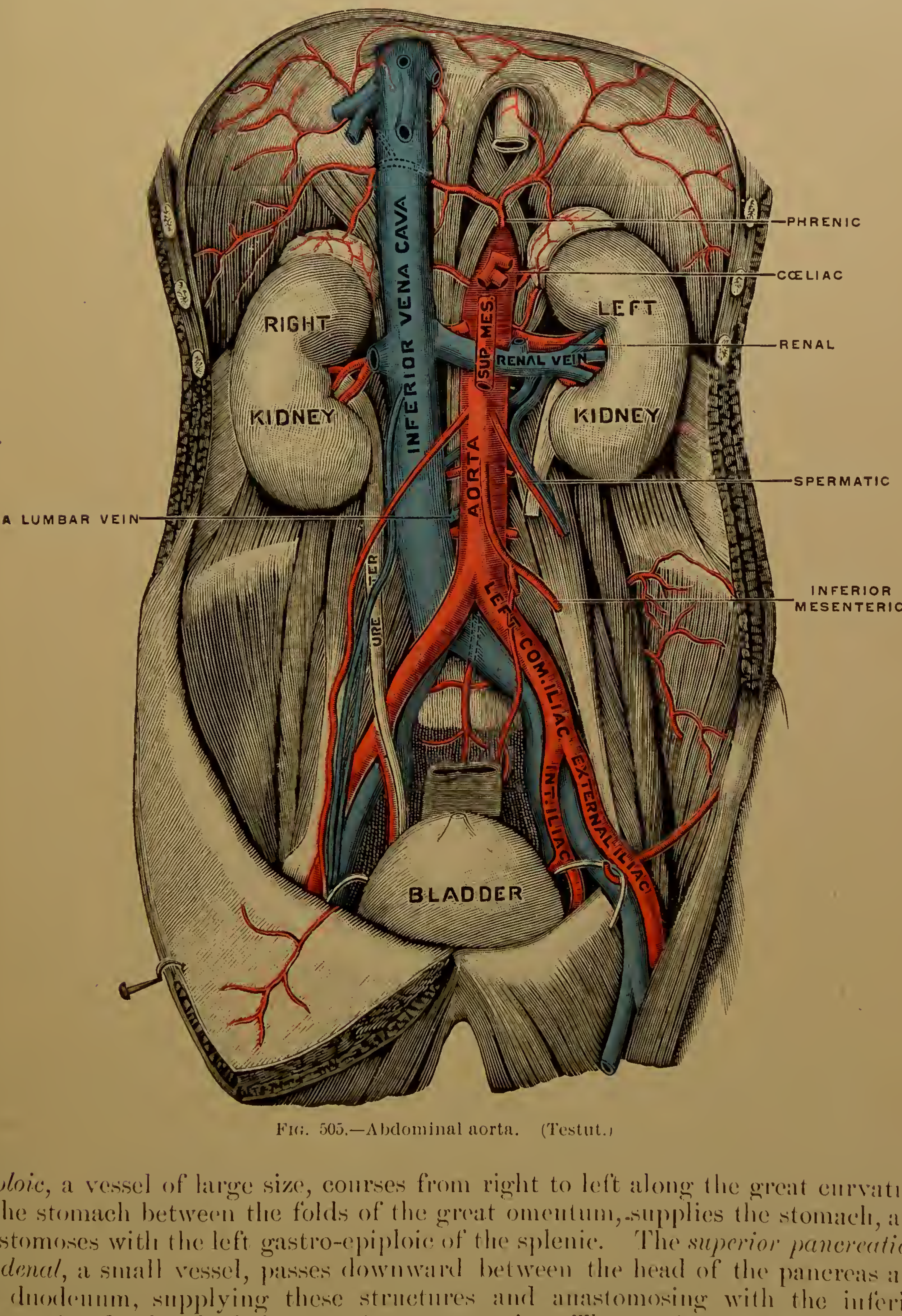


FIG. 505.—Abdominal aorta. (Testut.)

epiploic, a vessel of large size, courses from right to left along the great curvature of the stomach between the folds of the great omentum, supplies the stomach, and anastomoses with the left gastro-epiploic of the splenic. The *superior pancreatico-duodenal*, a small vessel, passes downward between the head of the pancreas and the duodenum, supplying these structures and anastomosing with the inferior pancreatico-duodenal of the superior mesenteric. The *cystic* artery supplies the gall-bladder. The *terminal* branches, right and left, supply the right and left lobes of the liver respectively.

The **splenic artery** is the largest branch of the cœliac axis; it runs from right to left, in a tortuous course, along the upper surface of the pancreas to the spleen.

The *branches* of the splenic artery are the pancreatic, the short gastric, the left gastro-epiploic, and the terminal. The *pancreatic* are numerous branches supplying the pancreas; one large trunk accompanies the main duct of the pancreas from left to right, and is called the great pancreatic. The *short gastric*, half a dozen vessels of small size, supply the left extremity of the stomach. The left *gastro-epiploic* winds along the great curvature of the stomach, and anastomoses with the right gastro-epiploic. The *terminal* branches, five or more in number, radiate from the end of the artery, and enter the hilum of the spleen.

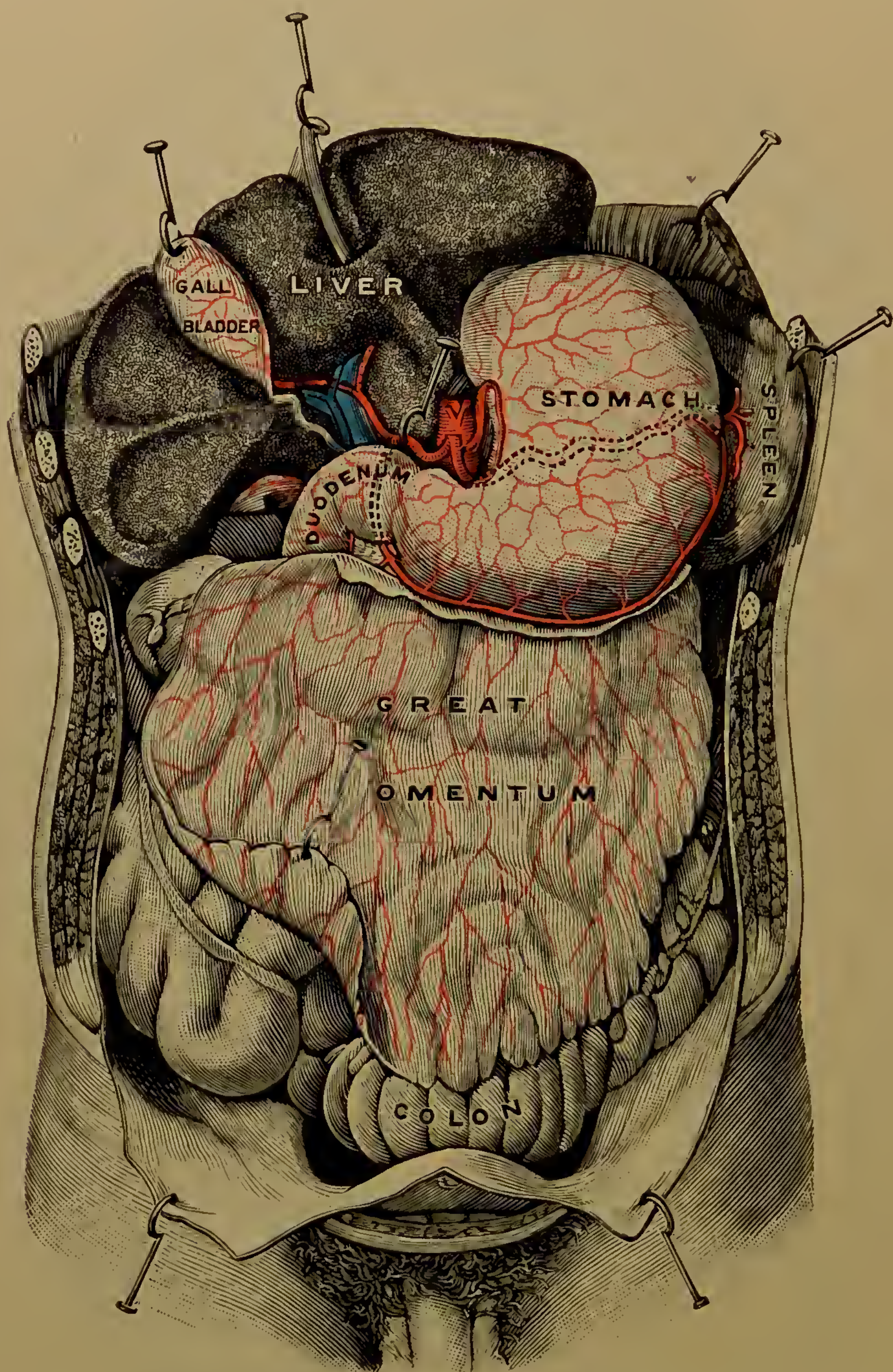


FIG. 506.—Arteries of the stomach, liver, and great omentum. (Testut.)

The Superior Mesenteric Artery (Fig. 507), a vessel of great size, arises from the anterior surface of the abdominal aorta below the cœliac axis and behind the pancreas. It passes downward and to the right between the folds of the mesentery, and breaks up into branches which supply the small intestines (except the upper part of the duodenum), the cæcum, and the ascending and transverse colon. It sometimes gives off a hepatic branch, and occasionally supplies the descending colon. Although the branches anastomose freely in the mesentery, when they reach the intestine and are distributed to it they pass between its walls at right angles to its long axis, and do not anastomose freely with one another; and, as a result of

this fact, a separation of the mesentery for any considerable extent from the intestine cuts off the blood-supply of the gut, and gangene results.

The *branches* of the superior mesenteric are the inferior pancreatico-duodenal, the middle colic, the right colic, the ileo-colic, and the arteries of the small intestine. The *inferior pancreatico-duodenal* runs between the duodenum and the head of the pancreas, supplying them, and anastomosing with the superior pancreatico-duodenal. The *middle colic* (colica media) is given off to the right, passes upward, and divides into two branches, the left inosculating with the left colic, the right with the right colic. It supplies the transverse colon. The *right colic* (colica dextra) runs to the ascending colon, and anastomoses above with the middle colic, below with the ileo-colic. The *ileo-colic* passes downward and to the right, and divides

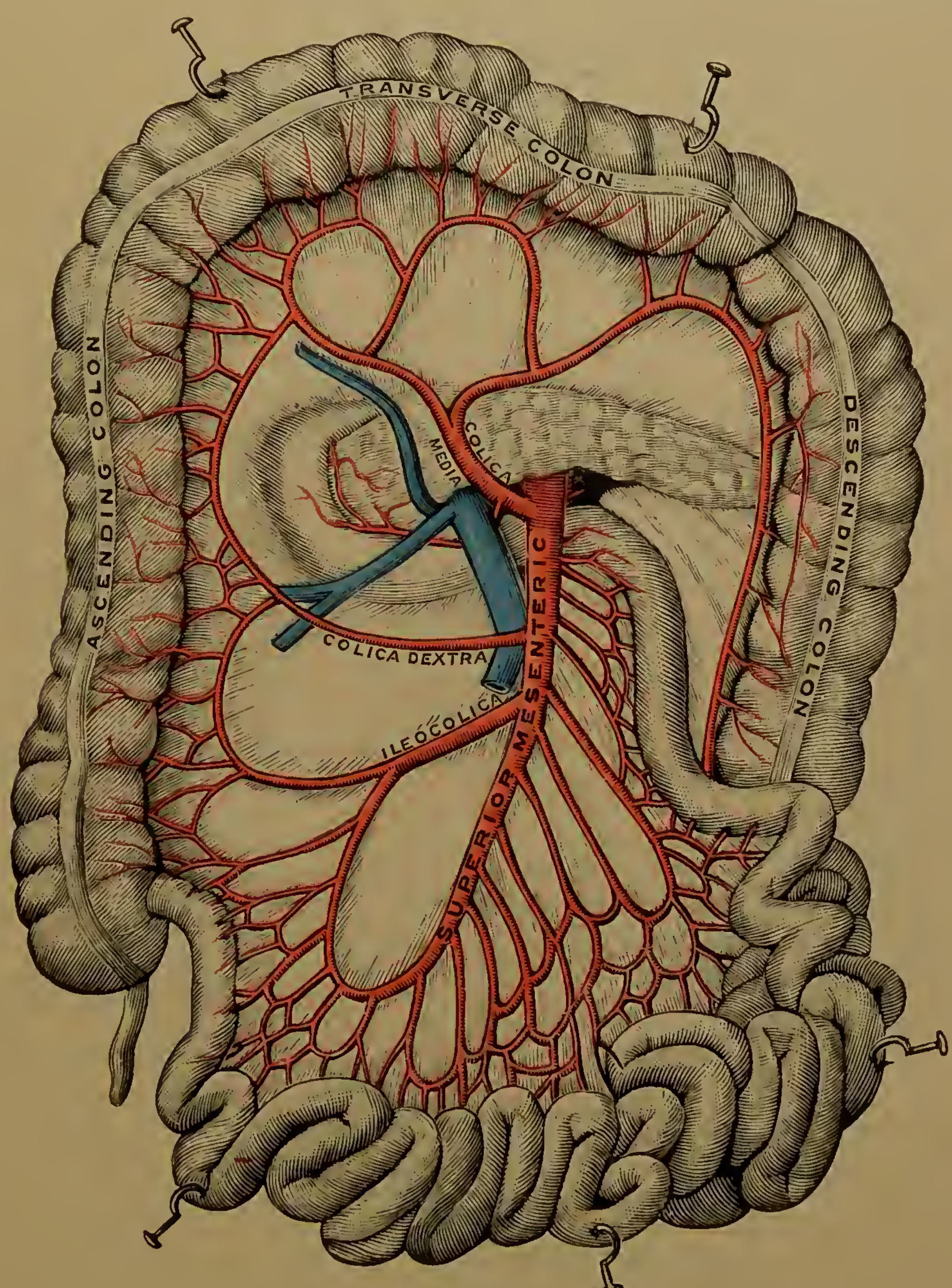


FIG. 507.—Superior mesenteric artery. (Testut.)

into two branches, one of which inosculates with the right colic, the other with the end of the superior mesenteric. The ileo-colic supplies the lower part of the ascending colon, the cæcum, and the appendix. The *arteries of the small intestine* (arteria intestini tenuis) pass in the mesentery to all portions of the small intestine except the upper part of the duodenum.

The Inferior Mesenteric Artery (Fig. 508).—The inferior mesenteric arises about an inch and a half above the termination of the aorta. It passes downward and to the left between the layers of the meso-colon, and supplies the left portion of the transverse colon, the descending colon, and the sigmoid colon. It is occasionally absent, its place being supplied by branches from the superior mesenteric.

Branches of the inferior mesenteric are the left colic, the sigmoid, and the

superior hemorrhoidal. The *left colic* (colica sinistra) supplies the descending colon, and anastomoses with the middle colic of the superior mesenteric and with the sigmoid branch. The *sigmoid* supplies the sigmoid colon, and anastomoses with the left colic and the superior hemorrhoidal. The *superior hemorrhoidal* is the direct continuation of the main artery, and passes in the sigmoid mesocolon to the beginning of the rectum. It anastomoses with the middle hemorrhoidal.

(For a description of the plan of division of the large intestine adopted in this work, the reader is referred to the chapter on the digestive organs.)

The Suprarenal Artery.—The *suprarenal* is a vessel of small size, which arises from the lateral surface of the aorta a little above the origin of the superior

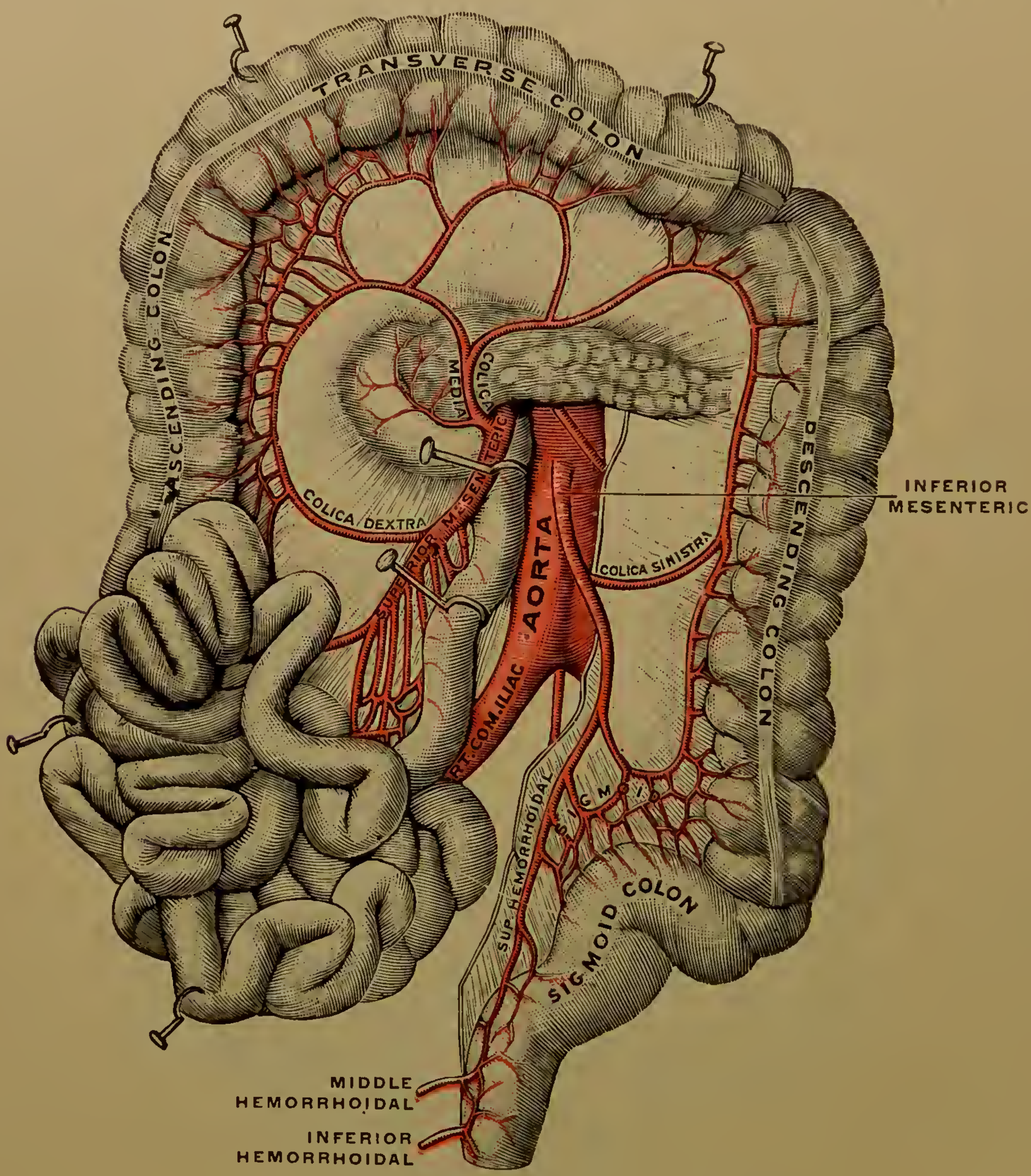


FIG. 508.—Inferior mesenteric artery. (Testut.)

mesenteric, and passes transversely outward to the suprarenal body, which it supplies.

The Renal Artery.—The *renal artery* is a vessel of very large size, which arises from the lateral surface of the aorta about half an inch below the origin of the superior mesenteric. It passes transversely outward to the hilum of the kidney, where it rapidly breaks up into branches supplying this organ. In its course it is in contact with the renal vein in front and the ureter behind. In one case in five an additional renal artery exists, and there may be several.

The Spermatic Artery.—The *spermatic artery* arises from the anterior surface of the aorta below the renal artery, passes downward behind the peritoneum and in front of the psoas magnus muscle, crosses the ureter, enters the internal abdominal ring, and forms one of the structures of the cord. It is dis-

tributed to the testicle. The spermatic may spring from the renal, and both spermatics may come from a common trunk. Occasionally the artery is double on each side.

The Ovarian Artery of the female is the homologue of the spermatic. It takes the same course behind the peritoneum, but as it reaches the broad ligament it passes between its folds to the ovary, and sends a branch of some size to the uterus. The ovarian is subject to the same variations as those occurring in the spermatic.

The Phrenic Artery arises from the aorta above the cœliac axis, sometimes those of the two sides coming from a single trunk. It passes upward to the diaphragm, which it supplies, and anastomoses with the musculo-phrenic and superior phrenic branches of the internal mammary.

The Lumbar Arteries are the homologues of the intercostals. They are four or five in number on each side, and arise from the postero-lateral surface of the aorta. Passing outward behind the psoas magnus muscle, between the transverse processes of the lumbar vertebræ, each divides into a dorsal and an abdominal branch. The dorsal branch passes backward, supplies the deep muscles of the back, and gives off a spinal branch, which furnishes branches to the spinal cord and membranes and to the lumbar vertebræ. The abdominal branch passes either in front of or behind the quadratus lumborum muscle to the muscles of the abdominal walls, winds forward, and anastomoses with the intercostal arteries and branches from the external iliac, which supply the walls of the abdomen.

The Middle Sacral (sacra media) **Artery** arises from the lower end of the abdominal aorta, passes down the middle line of the last lumbar vertebra and sacrum, and to the tip of the coccyx, where it terminates in the structure known as Luschka's gland. It anastomoses freely in front of the sacrum with the lateral sacral arteries, and gives some branches to the rectum. It is sometimes a branch from a lumbar artery, sometimes from the common iliac.

THE COMMON ILIAC ARTERIES.

The *common iliac arteries* (Figs. 505, 509) take their origin from the aorta where it bifurcates opposite the fourth lumbar vertebra. They pass downward and outward behind the peritoneum to the articulation between the last lumbar vertebra and the sacrum, and divide into the external and internal iliac arteries.

The **Relations** of the common iliac arteries differ on the two sides, owing to the fact that the common iliac veins both pass to the ascending vena cava, which is at the right of the aorta.

The *right common iliac* lies at first in front of the lower end of the vena cava inferior and the upper end of the left common iliac vein, and in the rest of its course ventral to the right common iliac vein. It is crossed in front by branches of the sympathetic nerve and, low down, by the ureter, and is covered by peritoneum, in front of which is a portion of the small intestine.

The *left common iliac* in its upper part is in front of the fourth and fifth lumbar vertebræ and the cartilaginous disc between them; in its lower part it is ventral to the left common iliac vein. Branches of the sympathetic nerve, the ureter, and the superior hemorrhoidal artery cross it anteriorly, and it is covered by peritoneum, in front of which is the sigmoid colon.

Branches.—As a rule no large branches are given off from the common iliac in its course; but it sends twigs to the psoas, the ureter, and the peritoneum. Its terminal branches are the internal iliac and the external iliac arteries.

The common iliac bifurcates into two great arteries. One, the internal iliac, is destined to supply a large part of the viscera contained in the pelvis, the pelvic walls, the external genitals, the buttock, structures about the hip-joint, and the inner part of the thigh. The other and larger, devoted to the nourishment of a portion of the abdominal wall and the greater part of the lower limb, runs as a continuous trunk from its origin to below the knee-joint, presenting in its course

no intrinsic lines of division. To facilitate description, however, this great vessel is divided into three portions by extrinsic landmarks. The first part extends from the bifurcation of the common iliac to the inguinal ligament, and is called the external iliac artery; the second runs from the inguinal ligament to the opening in the adductor magnus, and is known as the femoral artery; and the third, beginning at the adductor opening, ends at the lower border of the popliteus muscle, and is named the popliteal artery

Variations.—The length of the common iliac varies with the point of bifurcation of the abdominal aorta. When the abdominal aorta bifurcates high up, as it does sometimes, on the third lumbar vertebra, the common iliacs are long. When the bifurcation is opposite the fifth lumbar we find very short common iliacs. In rare cases the common iliac is absent, the external and internal iliacs

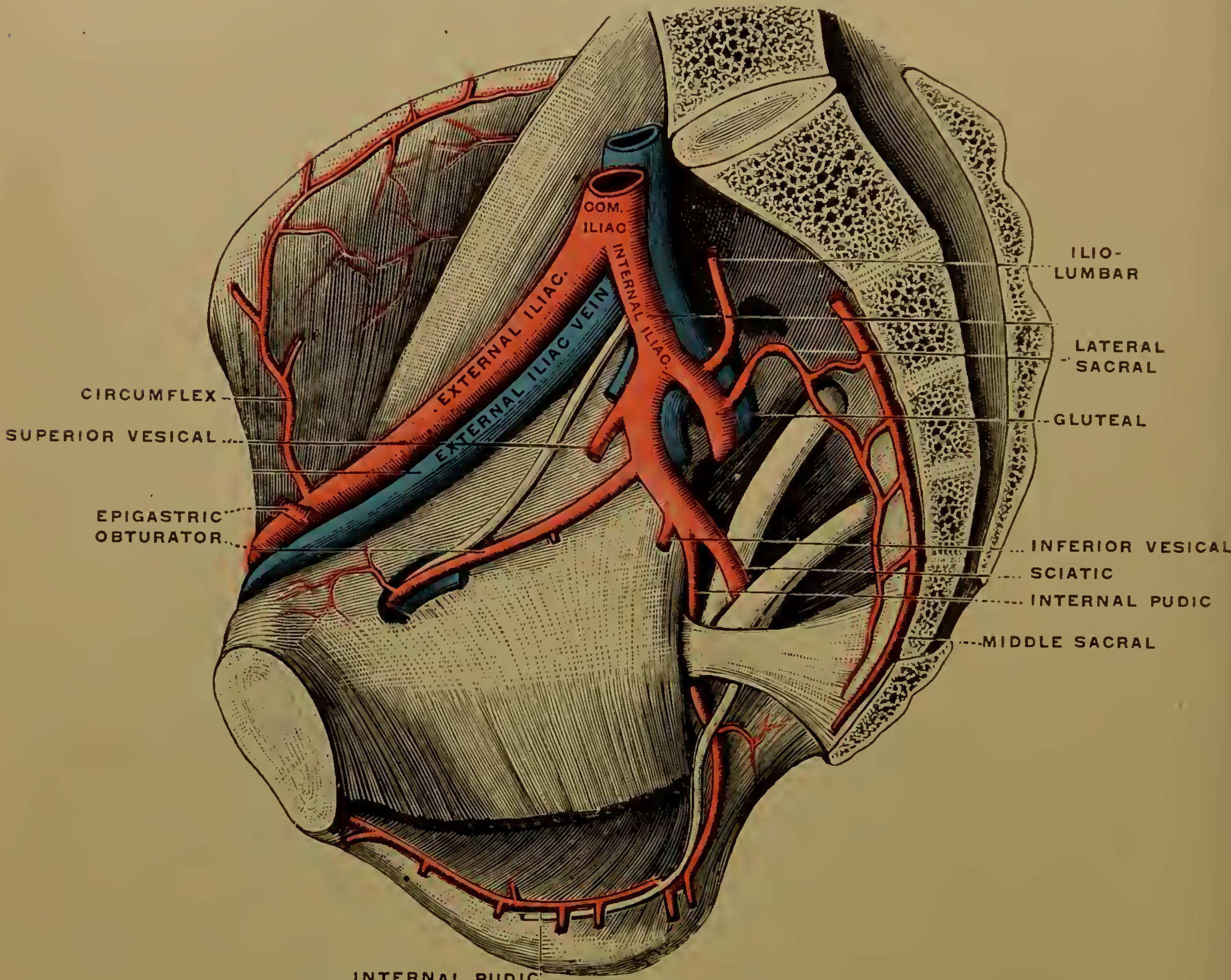


FIG. 509.—External and internal iliac arteries. (Testut.)

springing directly from the aorta. The common iliac sometimes gives off the middle sacral, a lateral sacral, a lumbar, or even the renal.

The Internal Iliac Artery.

The *internal iliac artery* (Fig. 509) takes its origin at the point of bifurcation of the common iliac opposite the articulation between the last lumbar vertebra and the sacrum, and runs downward to the upper border of the great sacro-sciatic foramen, where it bifurcates into an anterior and posterior trunk. Its branches are distributed to the viscera and walls of the pelvis, the genital organs, the perineum, the buttock, and the back and inner parts of the thigh.

Relations.—It is crossed in front by the ureter, and is covered by the peritoneum; and it has behind it the external and internal iliac veins, the lumbo-sacral cord, and the pyriformis.

Variations.—Its length varies from one to three inches. Sometimes the

branches are given off from the vessel without a previous division into an anterior and a posterior trunk.

Branches of the internal iliac artery. From the *anterior trunk* are given off the vesical, the middle hemorrhoidal, the uterine and vaginal in the female, the obturator, the internal pudic, and the sciatic arteries. From the *posterior trunk* are given off the ilio-lumbar, the lateral sacral, and the gluteal.

The Vesical Arteries are three in number, the superior, middle, and inferior vesical, which supply the bladder, ureter, prostate, and seminal vesicles. From the superior vesical a fibrous cord passes upward to the umbilicus. This is the remains of the hypogastric artery, which becomes obliterated after birth.

The Middle Hemorrhoidal Artery supplies the upper and middle portions of the rectum, anastomosing with the superior hemorrhoidal, a branch from the inferior mesenteric, and with the inferior hemorrhoidal, a branch from the internal pudic.

The Uterine Arteries are vessels of good size which run to the neck of the uterus, ascend along its lateral wall in the folds of the broad ligament to the fundus, and anastomose with the ovarian and vaginal arteries.

The Vaginal Arteries are, as a rule, two or three branches which supply the vaginal walls.

The Obturator Artery runs downward and forward to the upper part of the obturator foramen, and passes out of the pelvis through an opening in the upper part of the obturator fascia, to be distributed to the upper and inner aspect of the thigh.

From the portion of the artery within the pelvis several small branches are given off, an *iliac* (nutrient) branch to the iliac fossa, a *vesical* branch to the bladder, and a *pubic* branch, which runs upward along the inner margin of the femoral ring. In the thigh the obturator divides into an internal and an external branch. The *internal* passes downward on the inner surface of the thigh to be distributed to the adductor muscles. The *external* winds outward behind the femur to be distributed to the external rotators of the thigh.

The variations of the obturator are frequent, and should be carefully noted in connection with the study of femoral hernia. In almost one-third of dissections the vessel, instead of arising from the internal iliac, is a branch from the deep epigastric. In some cases it is given off from the external iliac. When the obturator is given off from the deep epigastric, it winds downward to the obturator foramen. In the majority of cases it is in close contact with the iliac vein, and, therefore, would be external to femoral hernia. In a small proportion of cases it winds along the inner border of the femoral ring and would be internal to a femoral hernia. In operations for the relief of strangulated femoral hernia this possibility must be borne in mind.

The Internal Pudic Artery (Figs. 509, 511) is one of the terminal branches into which the anterior trunk of the internal iliac divides, the other being the sciatic. It supplies the perineum and the external genitals. It is larger in the male than in the female. The internal pudic leaves the pelvis through the great sacro-sciatic foramen below the pyriformis muscle, winds over the spine of the ischium, enters the pelvis again through the small sacro-sciatic foramen, runs along the ascending ramus of the ischium and the descending ramus of the os pubis, enters the perineum, and bifurcates into the dorsal artery of the penis and the artery of the corpus cavernosum.

Branches.—The internal pudic gives off many small branches to the muscles contiguous to it. Besides these there arise the following: the inferior hemorrhoidal, the superficial perineal, the transverse perineal, the artery of the bulb, the artery of the corpus cavernosum, and the dorsal artery of the penis.

The **inferior hemorrhoidal** crosses the ischio-rectal fossa to reach the anal canal, to which it is distributed, as well as to the contiguous integument. It anastomoses with the other hemorrhoidal arteries.

The **superficial perineal** passes upward and forward beneath the superficial

perineal fascia, and supplies the superficial muscles and integument of the perineum, and the scrotum.

The **transverse perineal** (often a branch of the superficial perineal) runs along the transversus perinei, and supplies the back part of the perineum.

The **artery of the bulb** is given off from the internal pudic between the layers of the triangular ligament. It passes upward and inward to the bulb, which it supplies. This vessel and its branches often give rise to troublesome or even serious hemorrhage in the operation of external urethrotomy or median lithotomy,

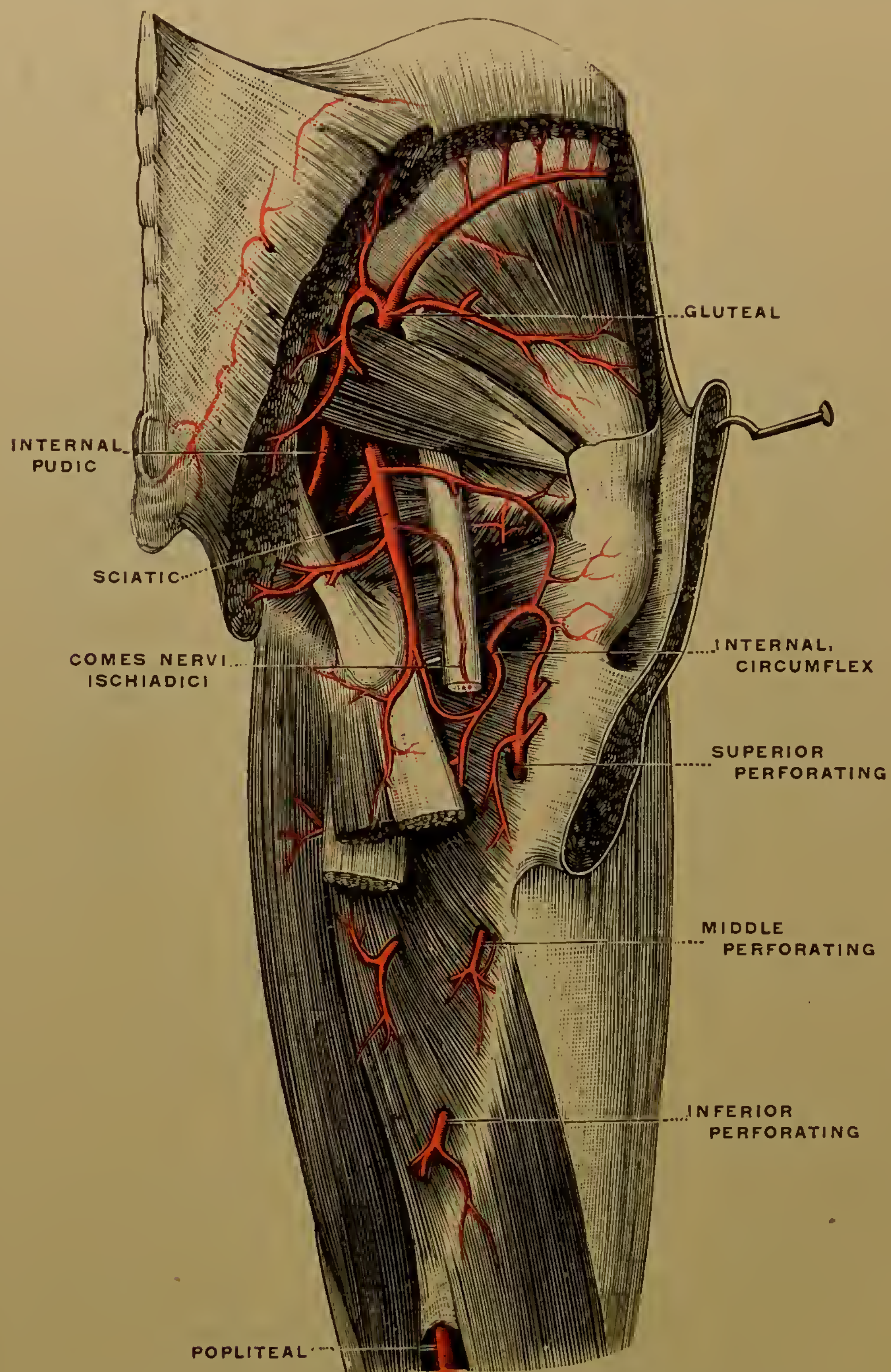


FIG. 510.—Arteries of the back of the hip and thigh. (Testut.)

in which the bulb is divided; and the artery may be wounded in operations for lateral lithotomy.

The **artery of the corpus cavernosum** runs upward and inward between the layers of the triangular ligament to the corpus cavernosum, which it supplies, breaking up into the cavernous spaces of that structure.

The **dorsal artery of the penis** passes upward to the suspensory ligament of the penis, which it pierces, and runs along the fibrous sheath of the upper surface of the penis to the glans, which it supplies. This vessel communicates with the artery of the corpus cavernosum.

The distribution of the internal pudic in the female is practically the same as in the male, but the vessel is smaller. The artery of the bulb supplies the bulbus vestibuli, and the terminal branches supply the clitoris.

The Sciatic Artery (Fig. 510) is one of the two terminal branches of the anterior trunk of the internal iliac. It leaves the pelvis through the great sacro-sciatic foramen below the pyriformis muscle, and passes down the back of the thigh in close company with the sciatic nerves to supply the buttock and upper portion of the posterior aspect of the thigh. It sometimes arises by a common trunk with the gluteal. Rarely it is a vessel of great size, and is the main source of blood for the lower extremity, practically taking the place of the femoral.

Within the pelvis the artery supplies small branches to the muscles with which it is in contact. After leaving the pelvis it gives off coccygeal, inferior gluteal, muscular and articular branches, and a branch which accompanies the sciatic

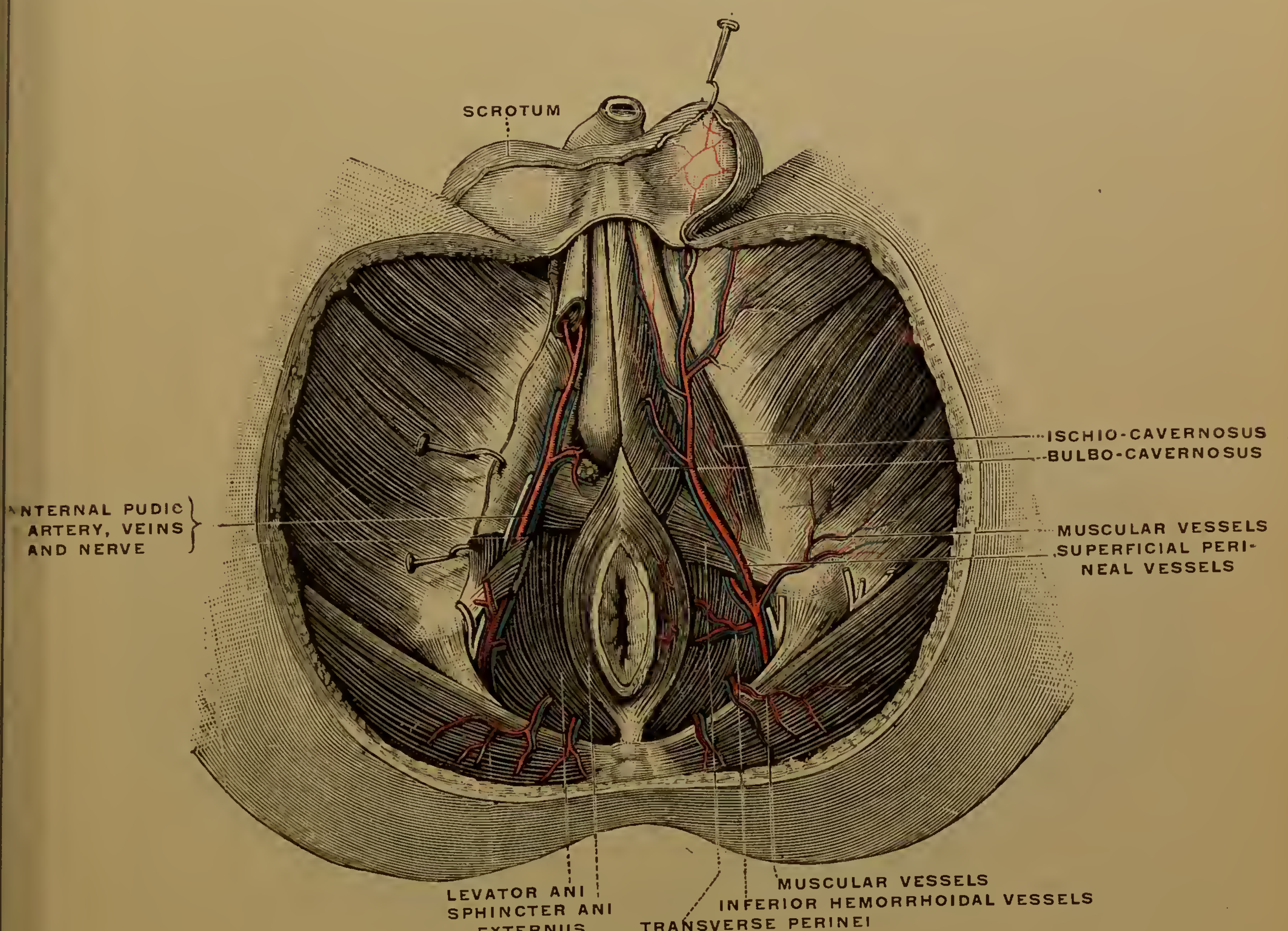


FIG. 511.—Arteries of the perineum. (Testut.)

nerve. The *coccygeal* branch supplies the tissues about the coccyx. The *inferior gluteal* branches supply the lower portion of the gluteus maximus muscle. The *comes nervi ischiadici* ("companion of the sciatic nerve") supplies the great sciatic nerve, running for some distance along its sheath. The *muscular* branches are distributed to the external rotator muscles of the thigh. The *anastomotic* takes part in the crucial anastomosis, which will be described later. The *articular* branch runs to the capsular ligament of the hip.

The *branches from the posterior trunk* of the internal iliac are the gluteal, the ilio-lumbar, and the lateral sacral.

The Gluteal Artery (Fig. 510) is a vessel of large size which leaves the pelvis through the great sacro-sciatic foramen above the pyriformis muscle. It then divides into a superficial and a deep branch. The superficial runs into the gluteus maximus muscle, and is distributed to its substance. The deep branch runs between the gluteus medius and gluteus minimus, and breaks up into two sets

of vessels, a superior and inferior, which supply these muscles. *Variations* of the gluteal are rare. The gluteal may arise by a common trunk with the sciatic, or may be absent, and its place be taken by a large branch from the femoral.

The **Ilio-lumbar Artery** passes outward behind the iliac vessels and psoas magnus muscle. Behind the muscle it divides into two branches; the lumbar, which is distributed to the psoas magnus and the quadratus lumborum muscles, and the iliac, which supplies the iliacus.

The **Lateral Sacral Arteries** are two in number, sometimes arising from a common trunk. They pass to the anterior surface of the sacrum, where they are distributed to the pyriformis and coccygeus muscles, and to the sacral nerves. Branches are sent into the anterior sacral foramina, where they supply the contents of the sacral canal and the bone.

The External Iliac Artery.

The *external iliac artery* (Figs. 505, 509), larger than the internal and about four inches long, arises from the division of the common iliac opposite the articulation between the last lumbar vertebra and the sacrum, and passes downward and outward behind the peritoneum and along the inner border of the psoas magnus muscle to the inguinal (Poupart's) ligament, where it becomes the femoral.

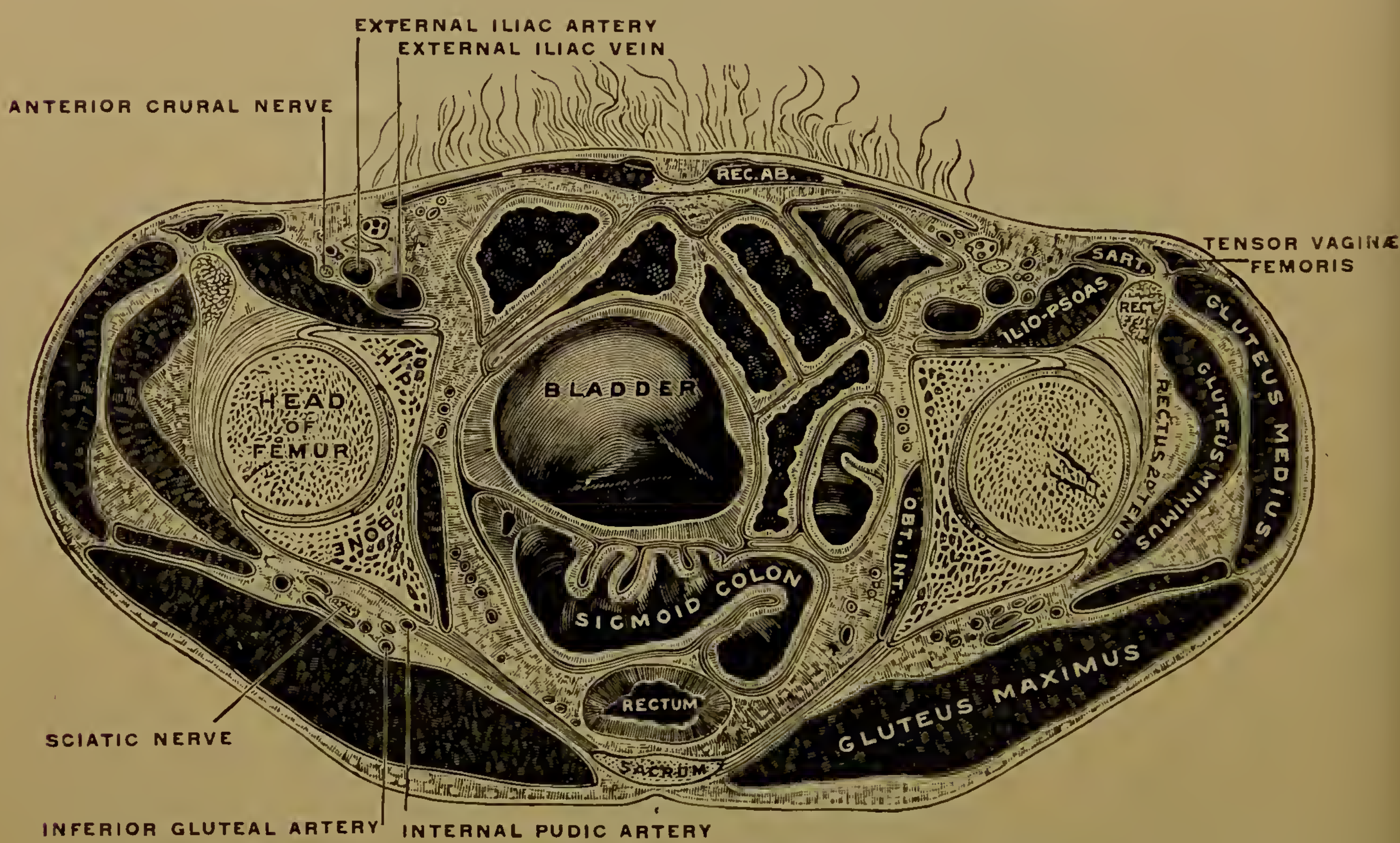


FIG 512.—Horizontal section three inches below the sacral promontory. The upper surface of the lower segment. (Testut.)

Relations (Fig. 512).—*In front* the peritoneum separates it from intestines; and in its lower part are the spermatic vessels, a branch of the genito-crural nerve, the deep circumflex iliac vein, and some lymph-nodes. *Behind* are the external iliac vein above, and the psoas magnus muscle below. *At the outer side* is the psoas. *At the inner side* are the external iliac vein, some lymph-nodes, and, in the male, the vas deferens.

Variations.—The external iliac is sometimes of small size; its resulting femoral is small, and the lower extremity usually then receives a large part of its blood supply from a large sciatic artery. The obturator is occasionally a branch of the external iliac.

The **Branches** of the external iliac are the deep epigastric, the deep circumflex iliac, and muscular.

The **Deep Epigastric** (Fig. 485) arises from the external iliac just above the inguinal ligament. It passes inward and a little downward at first, then upward and inward between the transversalis fascia and the peritoneum to the posterior surface of the rectus muscle, continues upward along the lower and inner margin of the internal abdominal ring, breaks into branches, which are distributed to the substance of the rectus, and anastomoses with the superior epigastric branch of the internal mammary.

Variations.—The deep epigastric may take origin higher up from the external iliac, from any part of its course. As already noted, the deep epigastric very often gives off the obturator artery. It has an important relation to inguinal hernia. The vessel in the first part of its course is situated between the two rings, and will therefore be internal to an oblique hernia, and external to a direct hernia.

The *Branches* given off in the course of the deep epigastric are the cremasteric, pubic, and muscular. The *cremasteric* artery supplies the coverings of the spermatic cord. The *pubic* winds around the inner margin of the femoral ring, and anastomoses with a similar branch from the obturator. *Muscular* branches are distributed to the muscles of the abdominal wall.

The **Deep Circumflex Iliac Artery** arises from the outer surface of the external iliac just above the inguinal ligament. It runs upward and outward, covered by the transversalis fascia, to the anterior superior spine of the ilium. It then runs along the crest of the ilium between the transversalis and internal oblique to about its centre, pierces the abdominal muscles, and breaks up into branches supplying them. In its course it gives branches to the various adjacent muscles, and to the skin.

The Femoral Artery.

The *femoral artery* (Figs. 513, 515), the continuation of the external iliac, begins at the lower margin of the inguinal ligament, midway between the anterior superior iliac spine and the symphysis pubis. It runs down along the anterior and inner part of the thigh to the femoral opening in the adductor magnus, and there ends in the popliteal. Its course lies under the upper two-thirds of a line drawn from its origin to the adductor tubercle, the thigh being somewhat flexed and abducted. The proximal part of the artery is near the surface, and runs from the base to the apex of a region called Scarpa's triangle; the distal portion is deeply situated in a fibro-muscular passage named Hunter's canal. About two inches from its beginning the artery gives off a very large branch, the profunda (deep femoral); and for the purpose of discrimination the portion of the vessel above this point is called the *common femoral*, that below it the *superficial femoral*.

Scarpa's Triangle has its base upward at the inguinal ligament, its outer side is formed by the inner margin of the sartorius, and its inner by the mesial border of the adductor longus. In its floor from without inward are seen the iliacus, psoas, pectineus, adductor brevis, and adductor longus. It contains the upper part of the femoral artery and the branches given off from it, the corresponding portion of the femoral vein, the anterior crural nerve, and the superficial inguinal lymph-nodes.

Hunter's Canal is a three-sided, fibro-muscular canal, occupied by the distal portion of the femoral vessels and the internal saphenous nerve. A strong fibrous layer, extending in front of the vessels, and between the vastus internus on the outer side and adductores magnus and longus on the inner, forms its anterior boundary, and the muscles named make its other sides. Superficial to the canal is the sartorius muscle.

Variations.—The femoral may be very small, and terminate in the upper part of the thigh; and the lower limb in such cases receives its blood-supply in large part from a very large sciatic artery. The femoral has been seen to divide into two vessels and then unite to form a single popliteal. Variations in branches are frequently noted. The circumflex arteries, one or both, are sometimes derived

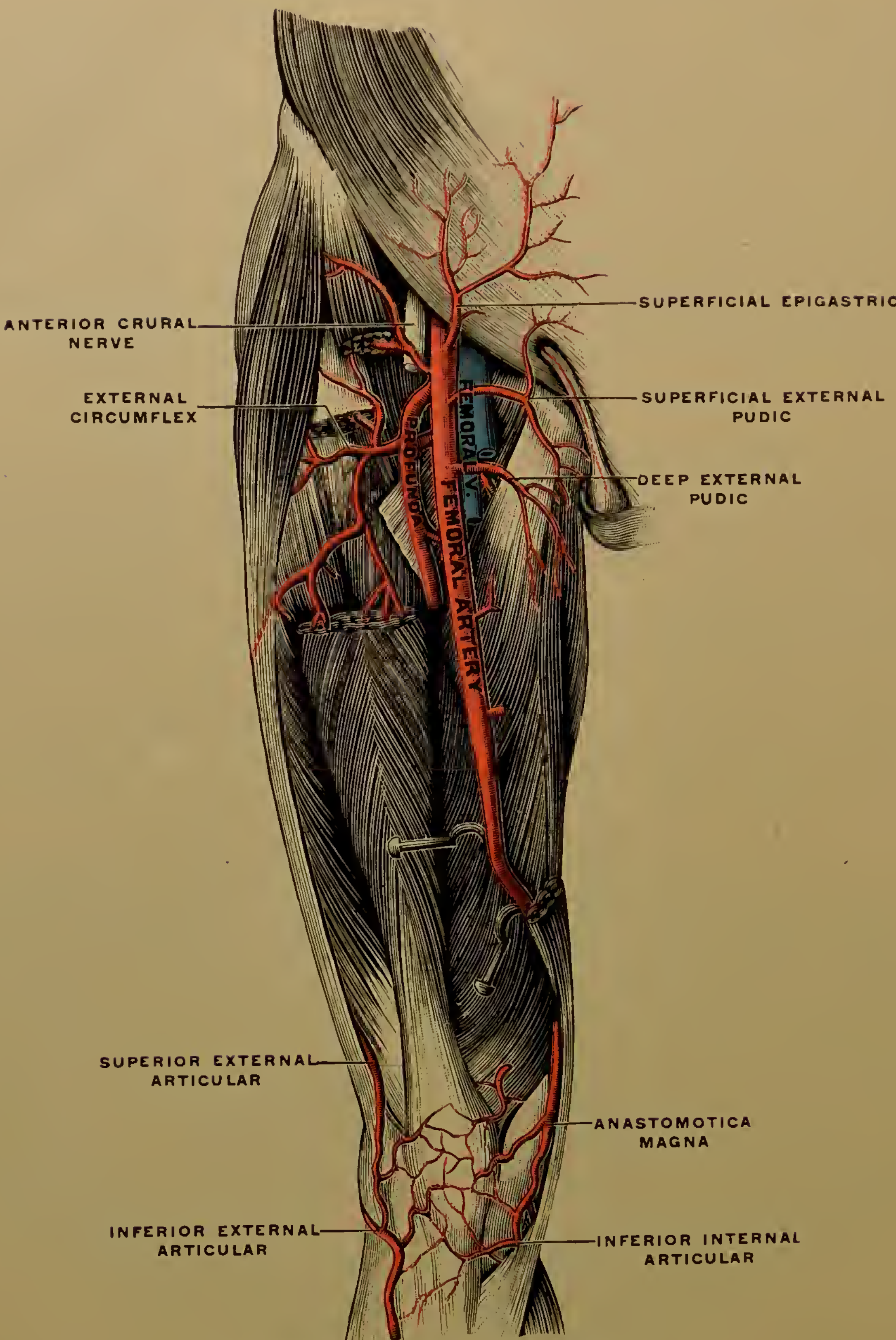


FIG. 513.—Femoral artery. (Testut.)

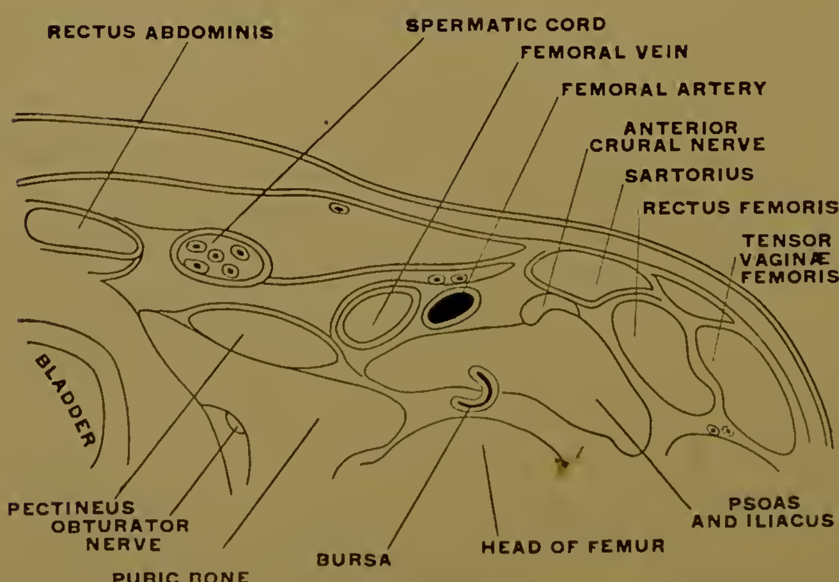


FIG. 511.—Horizontal section just above the symphysis pubis—the upper surface of the lower segment. The right side and ventral part of the section are in view. (Braune.)

from the common femoral instead of from the profunda. The profunda is sometimes given off from the inner side of the vessel instead of the outer side.

The Common Femoral Artery.

Relations (Fig. 514).—*In front*, in addition to the skin and subcutaneous areolar tissue, are the superficial inguinal lymph-nodes, the iliac portion of the fascia lata, branches of the genito-crural nerve, and the superficial circumflex iliac vein. *Behind*, in the upper part, the psoas intervenes between the vessel and the capsular

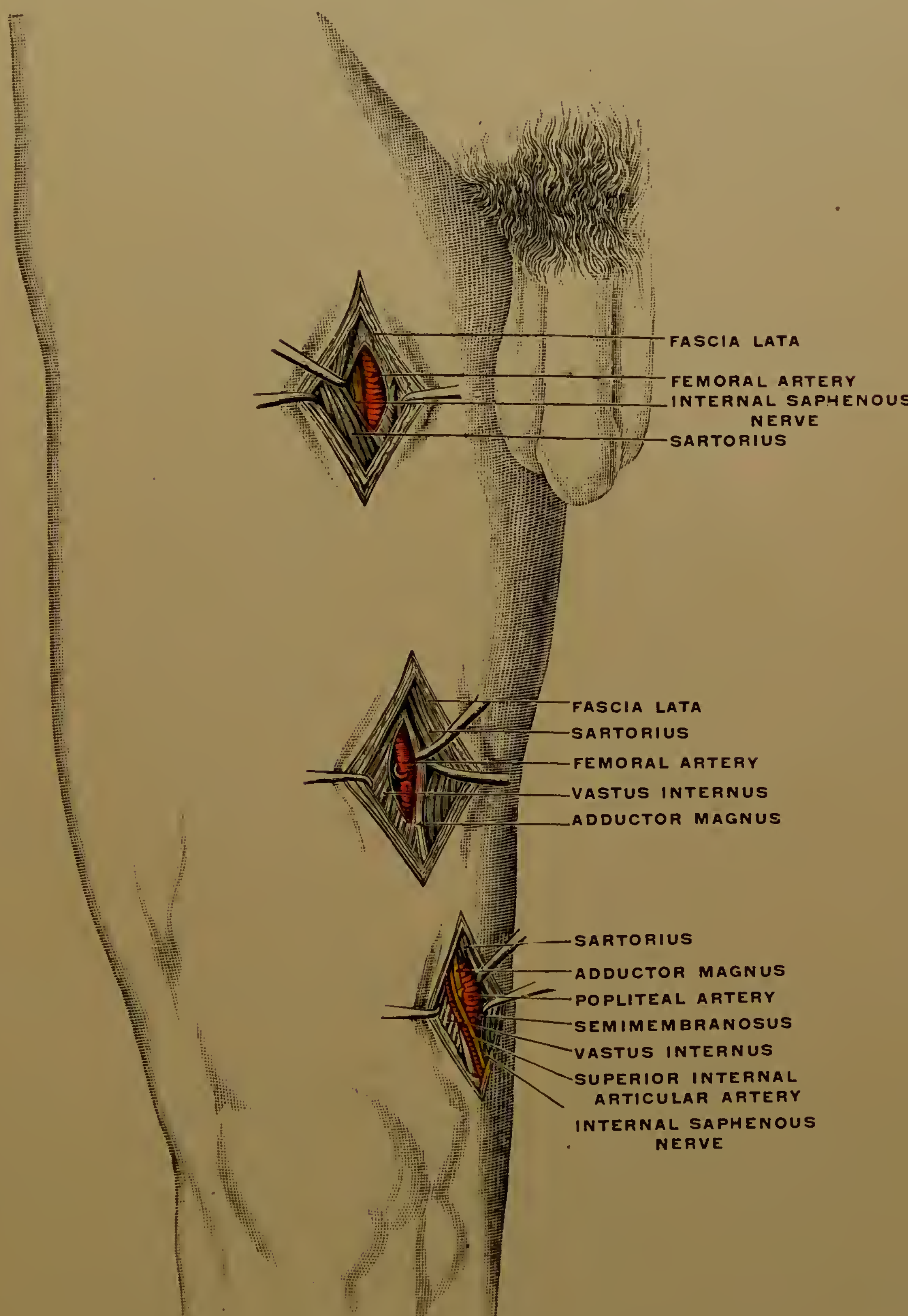


Fig. 515.—Surgical relations of the femoral artery. (Kocher.)

ligament of the hip-joint, and in the lower the pubic portion of the fascia lata separates it from the pectineus. *On the outer side* is the anterior crural nerve at a little distance. *On the inner side*, contained in the same sheath, is the femoral vein.

The Superficial Femoral Artery.

Relations (Figs. 516, 517).—**In Scarpa's triangle.**—*In front*, beneath the skin, areolar tissue, and fascia lata, is the internal cutaneous branch of the anterior

crural nerve. *Behind* are the pectineus and the profunda vessels above, the femoral vein below—the latter passing from within outward behind the artery. In the lower part is the adductor longus. *At the outer side* is the long saphenous nerve. *At the inner side* is the femoral vein.

In Hunter's Canal. *In front* are the internal saphenous nerve, and the fibrous wall of the passage, superficial to which is the sartorius. *Behind* are the femoral vein and the converging muscular walls of the canal. *At the outer side* are the vastus internus, and, below, the femoral vein. *At the inner side* are the adductor longus above, and the adductor magnus below.

The **Branches** of the femoral are the superficial epigastric, superficial circumflex iliac, superficial external pudic, deep external pudic, profunda (deep femoral), anastomotica magna, and muscular.

The Superficial Epigastric arises just below the inguinal ligament, passes through the saphenous opening, and turns upward onto the abdomen in front of

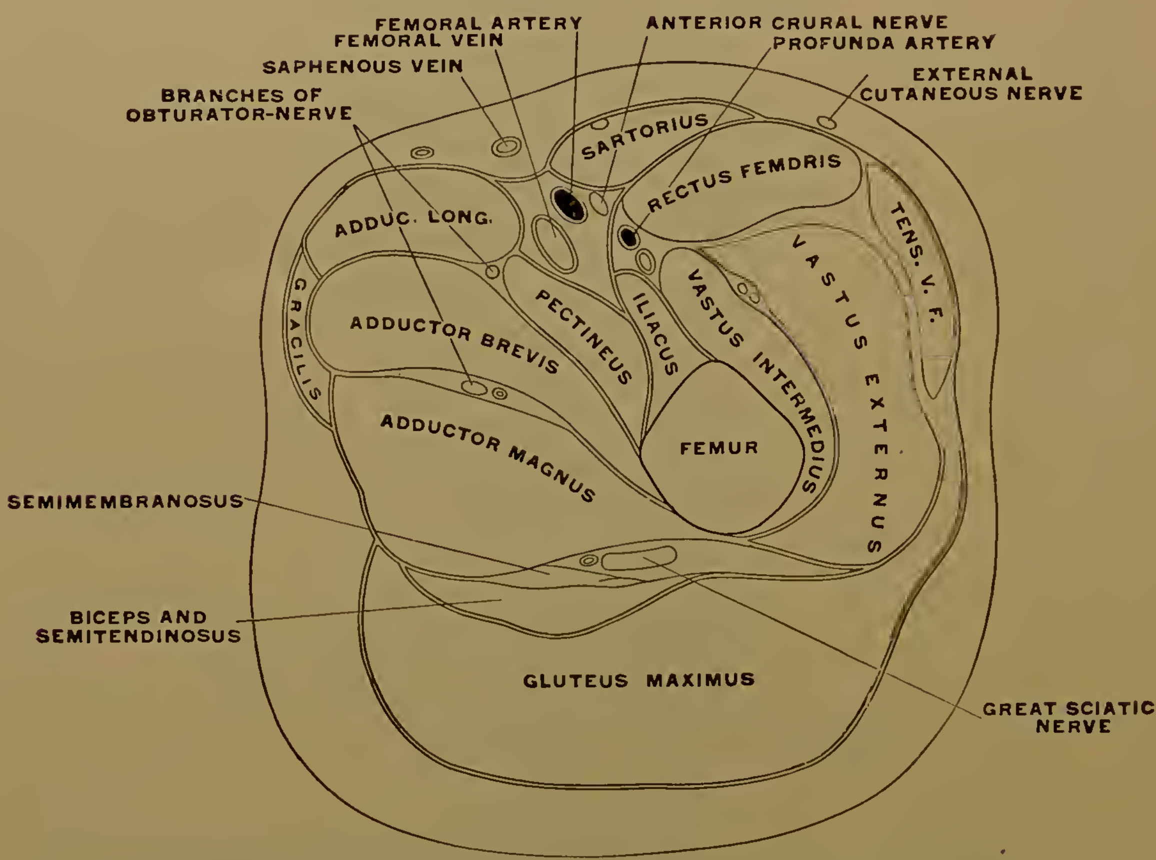


FIG. 516.—Horizontal section of the right thigh near the perineum—upper surface of lower segment. (Braune.)

the external oblique muscle, supplying the superficial inguinal lymph-nodes, and the integuments nearly up to the navel.

The Superficial Circumflex Iliac is given off near the preceding, and runs parallel to the inguinal ligament to the anterior superior iliac spine, and supplies the integuments and superficial inguinal lymph-nodes.

The Superficial External Pudic arises from the inner side a little below the last described, passes through the saphenous opening, then goes upward and inward, crossing the spermatic cord (or round ligament), and supplies the integuments in the hypogastric region and the skin of the external genitals.

The Deep External Pudic arises below or in common with the superficial, runs inward beneath the fascia lata, and supplies the skin of the scrotum (or labium majus) and the perineum.

The Profunda (Fig. 513) (*deep femoral*) supplies the most of the structures of the thigh. It is the largest branch of the femoral, and arises from the outer side, two inches or less from the upper end of the artery. It passes outward, downward, and backward, goes behind the femoral artery, and then down on the posterior surface of the adductor longus, perforates the adductor magnus, and ends

in the posterior, lower, and inner part of the thigh, the terminal vessel being sometimes considered the fourth perforating branch.

Relations.—*Behind* from above downward are the iliacus, pectineus, adductor brevis, and adductor magnus. *In front*, besides the skin and fasciæ, are the anterior crural nerve; then the femoral and profunda veins above, and the adductor longus below. *At the outer side* is the vastus internus. *At the inner side* above is the pectineus.

The *Branches* of the profunda are the external circumflex, the internal circumflex, and the three perforating.

The *External Circumflex* is given off from the outer side of the profunda, passes outward behind the sartorious and rectus among the branches of the anterior crural nerve, and divides into three sets of branches—the ascending, transverse, and descending. The *ascending* runs upward, and supplies the abductors of the thigh and the hip-joint. The *transverse* goes outward and winds around the femur below the great trochanter, supplying adjacent muscles. The *descending* passes down to the knee behind the rectus, and supplies that muscle and the

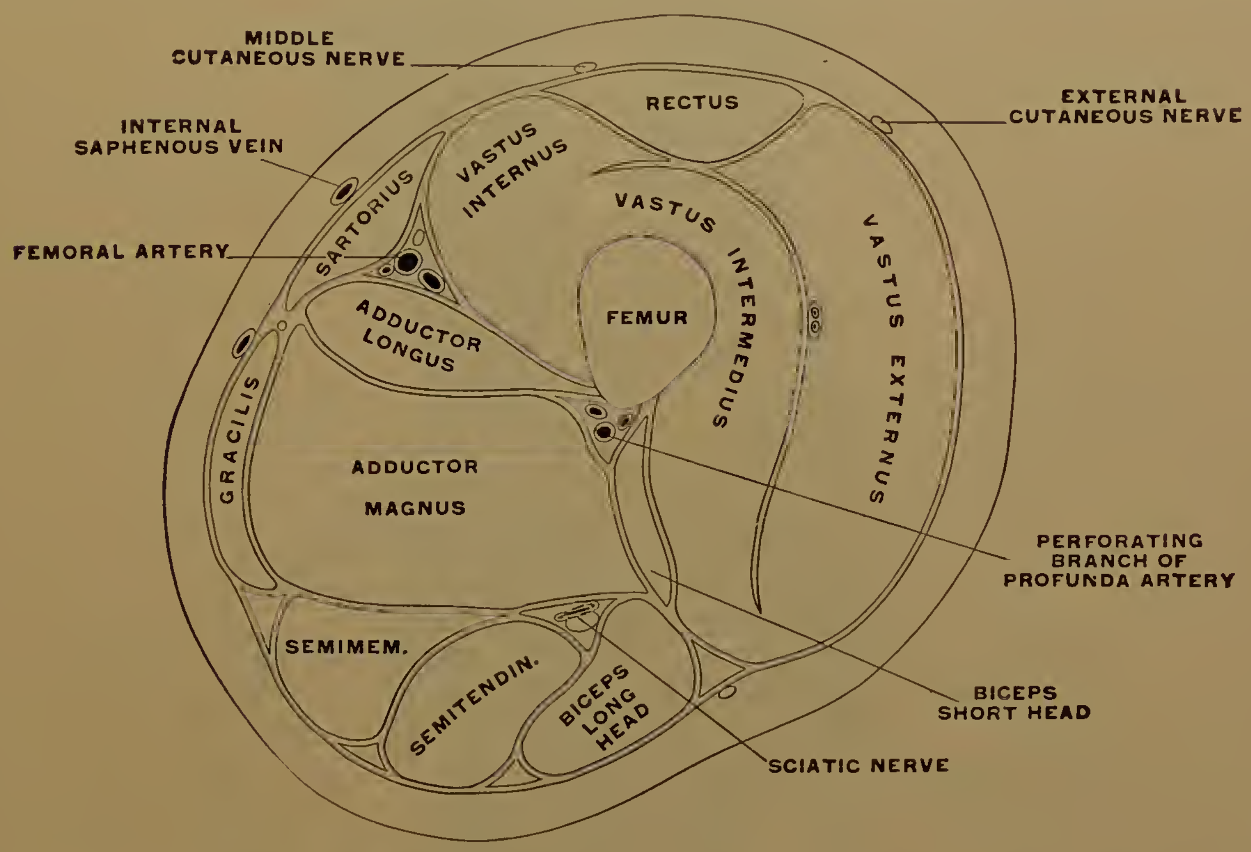


FIG. 517.—Horizontal section through the middle of the right thigh—upper surface of the lower segment. (Braune.)

vasti externus and intermedius. The *Internal Circumflex* arises from the inner side of the profunda nearly opposite the external, winds around the femur between the psoas and pectineus to the small trochanter, and gives off ascending and transverse branches. The *ascending* follows the obturator externus to the digital fossa. The *transverse* runs between the quadratus and adductor magnus, and inosculates with the external circumflex, sciatic, and superior perforating, forming the *crucial anastomosis*. The internal circumflex is distributed to the adductor group, the obturatur externus, the quadratus, and the hip-joint. The *Perforating*, usually three in number, named from their piercing the adductor magnus, are given off one above the adductor brevis, one in front of it, and one below it. Passing through the adductor magnus near the femur, they anastomose with one another, and are distributed principally to the flexors of the leg (hamstring muscles), the first additionally going to the adductor group and the gluteus maximus, and either the second or third giving the *nutrient* artery to the femur.

The preceding branches of the femoral all come from the common trunk.

In Scarpa's triangle the superficial femoral gives off no large branches, but only twigs to neighboring muscles.

In Hunter's canal several muscular branches arise, and also the anastomotica magna.

The Anastomotica Magna springs from the inner side of the femoral just above the lower end, and quickly divides into two branches. The *superficial* branch is distributed to the skin of the upper mesial surface of the leg; the *deep* branch runs down in front of the adductor magnus, enters into anastomosis in front of the knee, and sends branches to the joint and to the vasti internus and intermedius.

THE POPLITEAL SPACE.

The *Popliteal Space* ("ham-space") is a lozenge-shaped area at the back of the knee-joint. It is bounded above by the semitendinosus and semimembranosus

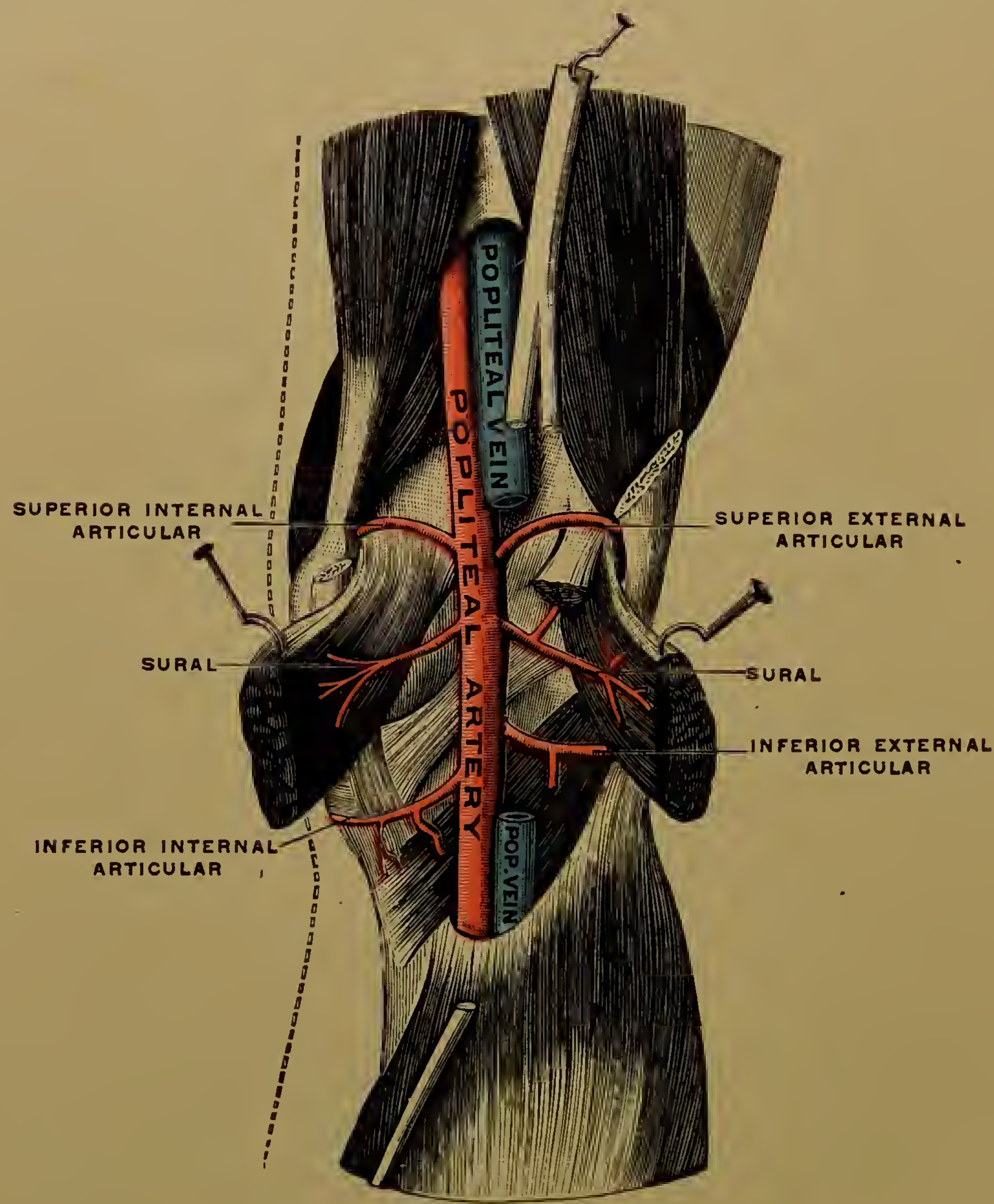


FIG. 518.—Popliteal artery. (Testut.)

mesially, and the biceps externally; below by the inner head of the gastrocnemius mesially, its outer head and the plantaris externally. Its floor from above downward presents the posterior surface of the femur, the posterior ligament of the knee, and the popliteus covered by its fascia. Its principal contents are the popliteal artery, the popliteal vein, and the internal popliteal nerve, these three standing in the order given, the artery deepest. The external popliteal nerve runs along the outer and upper wall of the space, sheltered by the biceps. A large bursa and some lymph-nodes are also found, together with adipose tissue. Before dissection the sides of the space are hardly an inch apart at the farthest. In flexion of the knee a depression is visible, but in extension there is a little bulging.

The Popliteal Artery.

The *Popliteal Artery* (Figs. 518, 520) is the third and last portion of the great arterial trunk, which begins at the bifurcation of the common iliac. It starts at the adductor opening, passes downward and a little outward through the popliteal space from its upper to its lower angle, and divides at the lower border of the popliteus muscle into the posterior and anterior tibial. It supplies the limb below its origin.

Relations.—*In front* are the structures that form the floor of the popliteal space. *Behind* are the popliteal vein, which is external to it above, and, crossing obliquely, gets to its mesial side below; the internal popliteal nerve, which is superficial to the vein, and crosses it from without inward; the semi-membranosus above, the gastrocnemius and plantaris below. At the inner and outer sides are the muscles which bound the popliteal space.

Variations.—The popliteal sometimes divides into three branches, the anterior tibial, the posterior tibial, and the peroneal; at times into the anterior tibial and

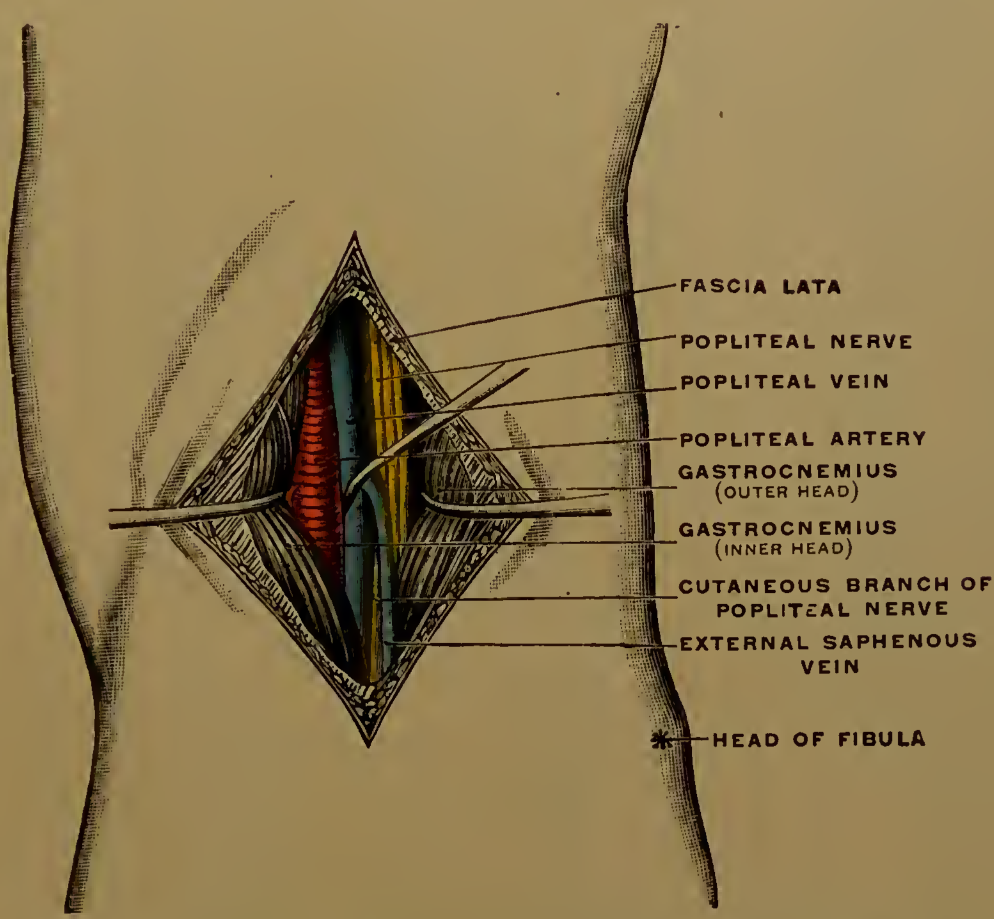


FIG. 519.—Surgical relations of the popliteal artery. (Kocher.)

peroneal, the peroneal supplying the place of the posterior tibial. Sometimes a high division of the popliteal occurs opposite the knee-joint.

Branches.—The popliteal has muscular, cutaneous, articular, and terminal branches. The *muscular* occur in two sets: the *superior*, which supply the hamstring muscles and the adductor magnus; and the *inferior* or *sural* ("calf"), which are distributed to the gastrocnemius, plantaris, soleus, and popliteus. The *cutaneous*, given off low down, supply the integument of the calf. The *articular* branches are five in number—the superior internal, the superior external, the azygos, the inferior internal, and the inferior external—and supply the joint and contiguous structures. The *azygos* arises from the anterior surface of the popliteal, and passes forward into the joint. The *superior* wind around the limb above the joint, the *inferior* just below it, and participate in intricate anastomoses about the patella with one another and with branches from neighboring arteries. The *terminal* branches of the popliteal are the posterior tibial and the anterior tibial.

The Posterior Tibial Artery.

The *Posterior Tibial Artery* (Figs. 520, 521), larger than the anterior, runs downward, and then downward and a little inward from the bifurcation of the popliteal to a point between the internal malleolus and the calcaneum, where it divides into the external and internal plantar. As its name implies, it is in the back part of the leg on the tibial side. It courses between the superficial and deep layers of muscles, and in front of the deep transverse fascia. It supplies through the branches given off in its course substantially the whole of the leg, excepting the structures in front of the interosseous membrane.

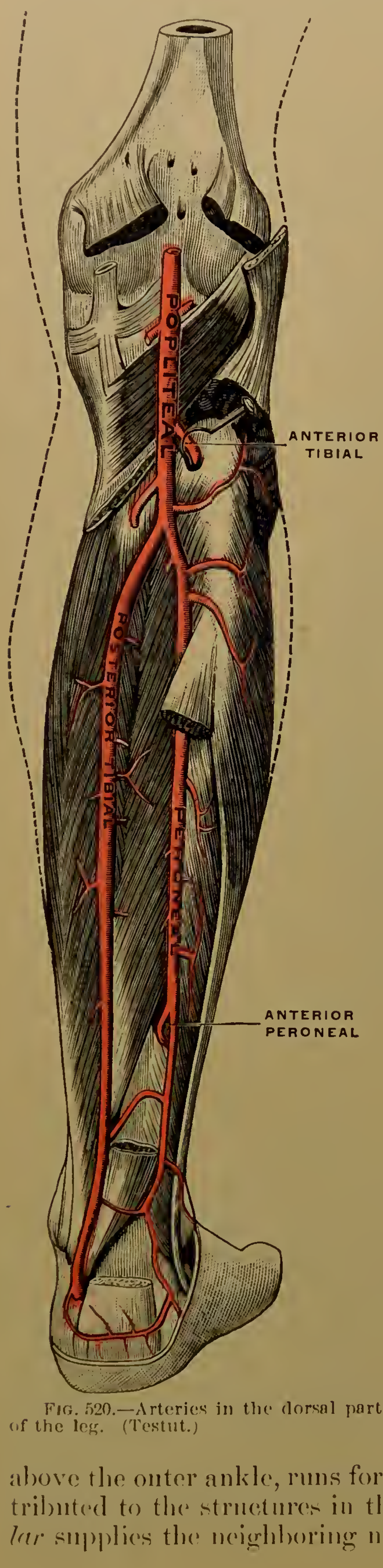


FIG. 520.—Arteries in the dorsal part of the leg. (Testut.)

Relations (Figs. 526–528).—*In front*, in order from above downward, are the tibialis posterior, the flexor longus digitorum, the tibia, and the internal lateral ligament of the ankle. *Behind* are the posterior tibial nerve in the greater part of its course, the deep transverse fascia, and, at its lowest part, the internal annular ligament, and the abductor hallucis. *At each side* is a companion vein.

Between the tip of the inner malleolus and the calcaneum the parts are arranged from before backward thus: the tibialis posterior, the flexor longus digitorum, the posterior tibial artery, the posterior tibial nerve, and the flexor longus hallucis—the artery in the middle of the group.

Variations.—The posterior tibial may be small, its place being taken by a large peroneal artery. The vessel may arise from a high division of the popliteal.

Branches.—The posterior tibial gives off the peroneal, the muscular, the nutrient, the communicating, the internal calcaneal, the external plantar, and the internal plantar.

The Peroneal (Figs. 520, 522), so called from its location near the fibula, is a large vessel and is given off about an inch below the origin of the posterior tibial. It runs outward and downward to the fibula, and then downward along its postero-internal border, either on or in the substance of the flexor longus hallucis, then across the lower tibio-fibular articulation, and ends in branches on the back of the external malleolus and outer side of the calcaneum. It is distributed to the fibula, and other structures in the back and outer side of the leg, and the outer half of the tarsus.

Branches.—The peroneal has the anterior peroneal, muscular, nutrient, communicating, which are given off in its course, and the external calcaneal and posterior peroneal, which are terminal. The *anterior peroneal* arises two inches above the outer ankle, runs forward through the interosseous membrane, and is distributed to the structures in the front and outer parts of the tarsus. The *muscular* supplies the neighboring muscles. The *nutrient* is the medullary artery of the

fibula. The *communicating*, a low branch, anastomoses with the *communicating* of the posterior tibial about an inch above the ankle-joint behind. The *external calcaneal* goes to the outer side of the os calcis. The *posterior peroneal* runs behind the external malleolus to the rear and outer surfaces of the calcaneum.

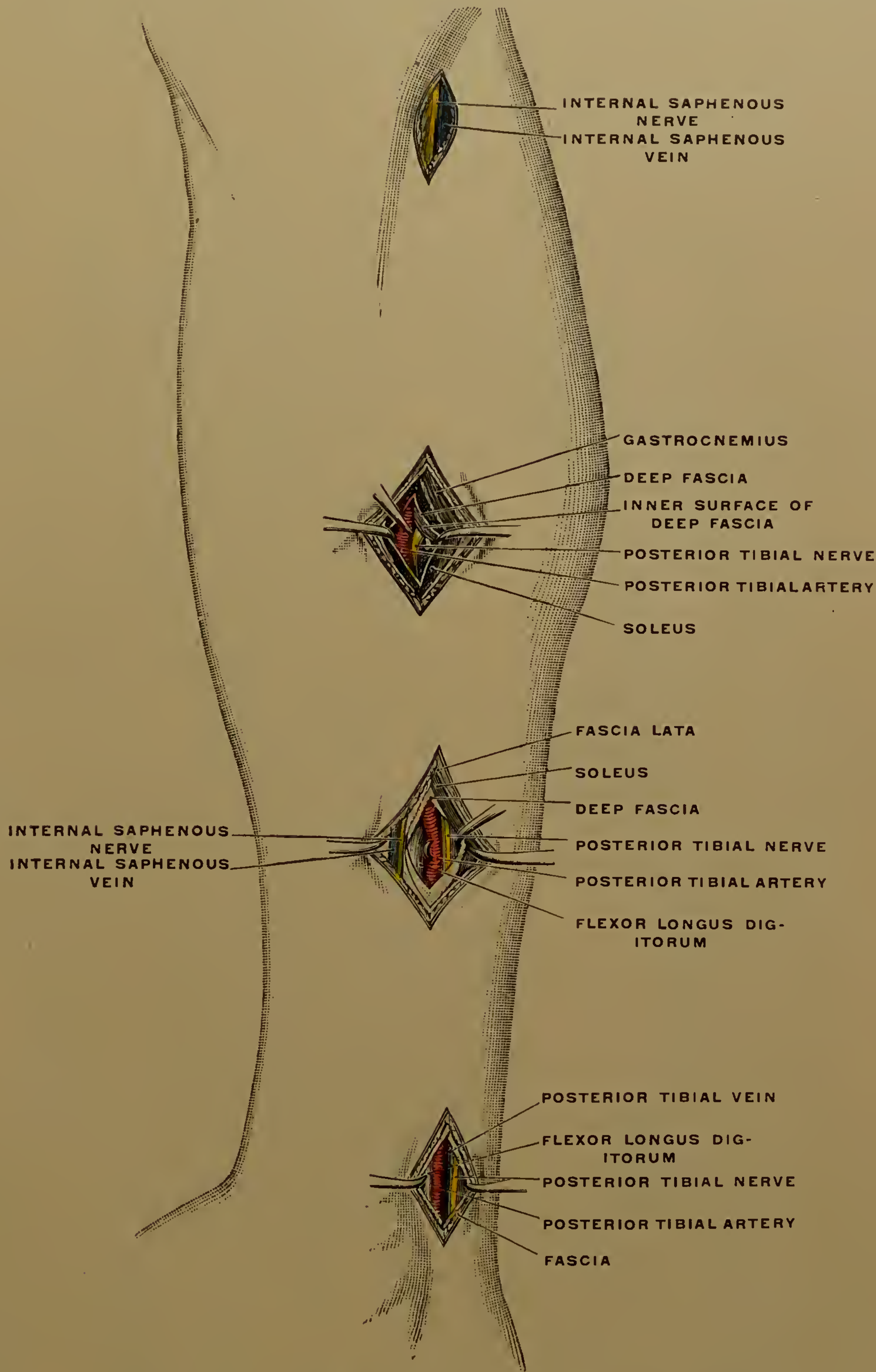


FIG. 521.—Surgical relations of the posterior tibial artery. (Kocher.)

The Muscular branches of the posterior tibial supply the muscles contiguous to that vessel.

The Nutrient, a high branch of the posterior tibial of large size, enters the tibia on its posterior surface.

The Communicating, given off low down, runs outward across the tibia above the ankle-joint, and inosculates with a corresponding branch of the peroneal.

The Internal Calcaneal—frequently several—are given off just above the

bifurcation, and supply the heel and the muscles of the mesial portion of the sole.

The External Plantar (Fig. 523), the larger of the terminal branches, passes outward and forward to the base of the fifth metatarsal bone, then curves forward and inward on the bases of the fourth, third, and second metatarsals to the first interosseous space, where it anastomoses with the deep (communicating) branch of the dorsalis pedis. Thus is formed the *plantar arch*.

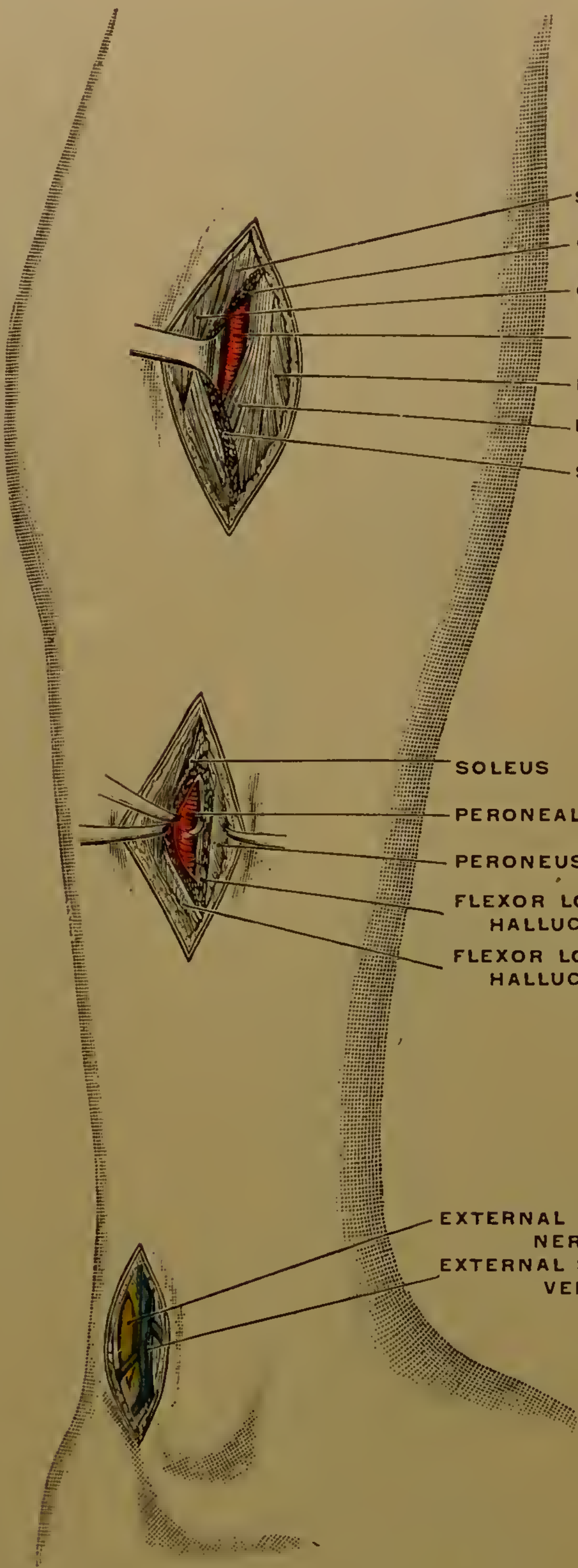


FIG. 522.—Surgical relations of the peroneal artery. (Kocher.)

The external plantar gives many small branches to muscles, skin, fascia, articulations, and so forth in its region; but the principal are the digital and the perforating.

The four *digital branches* come off from the convexity of the plantar arch, the first running forward to the outer side of the little toe, each of the others occupying an interosseous space, dividing at the web of the toes into two *collateral digital* branches, which supply the contiguous surfaces of the fifth and fourth, fourth and third, and third and second toes respectively near their plantar aspect. Just

before the bifurcation of each digital it gives off an *anterior perforating* branch, which runs upward and enters a corresponding dorsal interosseous artery.

The *posterior perforating* branches spring from the plantar arch upward through the second, third, and fourth interosseous spaces, and enter the dorsal interosseous branches of the metatarsal.

The Internal Plantar (Fig. 523) runs along the inner side of the sole of the foot, covered by the abductor hallucis at first, and then placed between this muscle and the flexor brevis digitorum. It gives off branches to the various neighboring structures, and ends by supplying the inner border of the great toe.

The internal plantar may be larger than usual, and supply two or even more digits; in such cases the external plantar is correspondingly diminished in size.

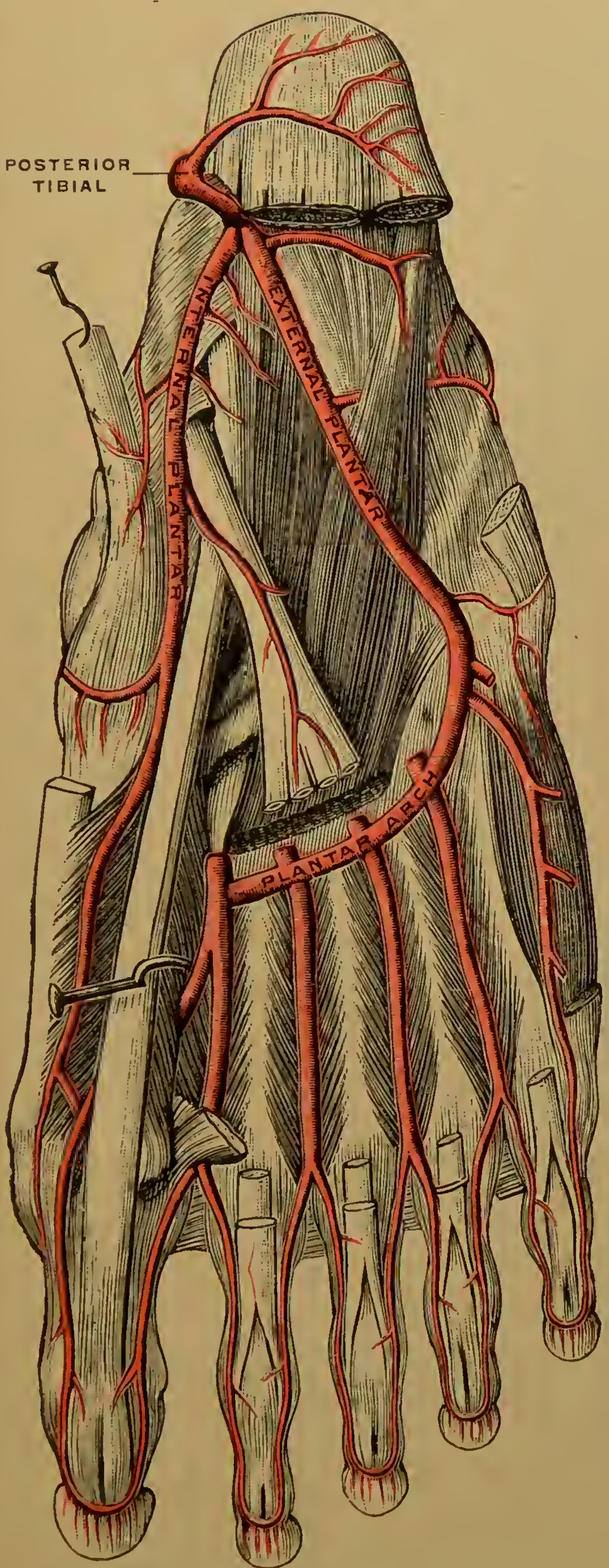


Fig. 523.—Arteries in the sole of the foot. (Testut.)

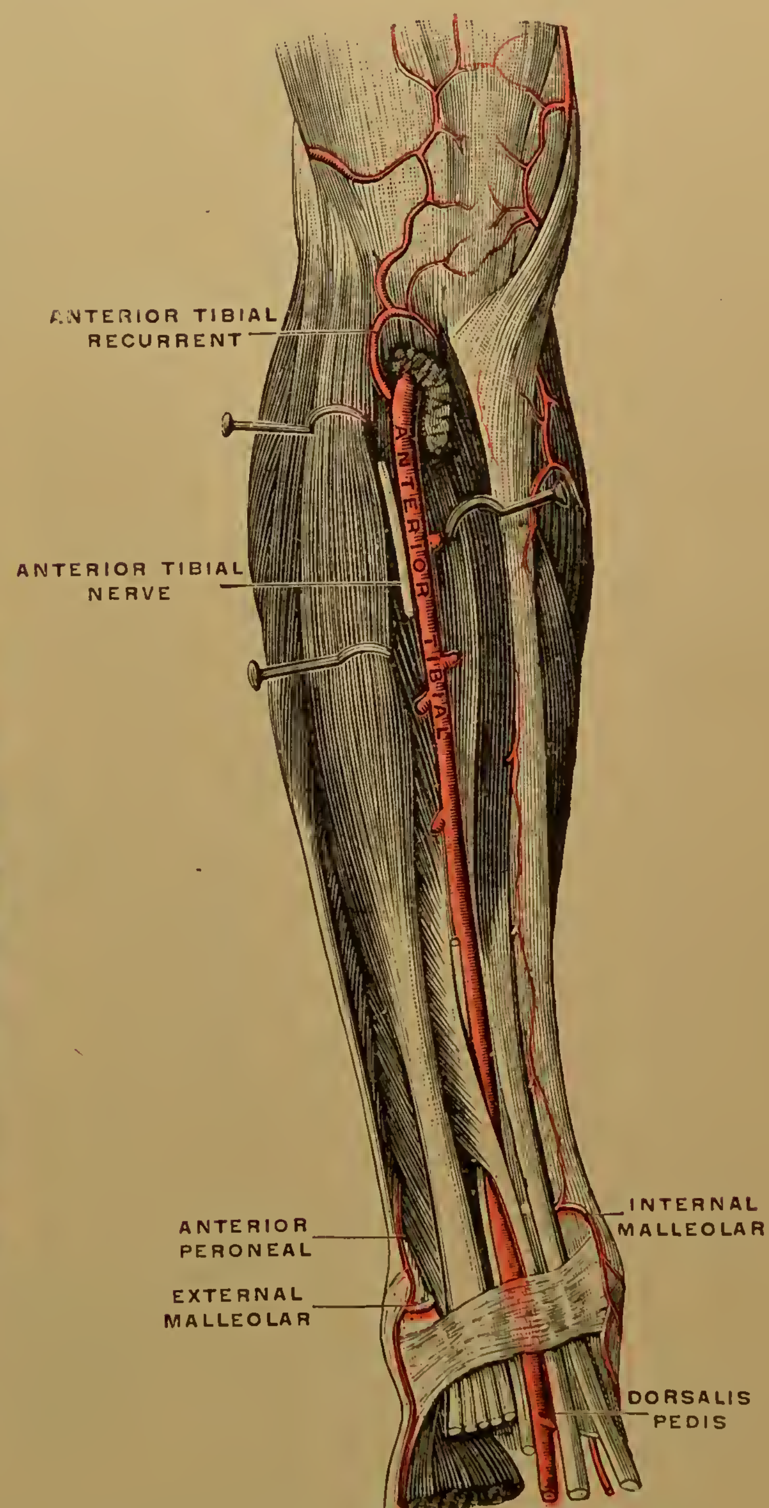


Fig. 524.—Anterior tibial artery. (Testut.)

The Anterior Tibial Artery.

The *anterior tibial artery* (Figs. 524, 525), smaller than the posterior tibial, begins at the lower border of the popliteus, passes forward between the heads of

origin of the tibialis posterior and above the upper edge of the interosseus membrane, upon the anterior surface of which it runs down, drifting toward the tibia, upon which and the anterior ligament of the ankle it courses. Its continuation in the foot is called the dorsalis pedis. Its branches mainly supply the structures in the anterior part of the leg.

Relations (Figs. 526–528).—*In front*, in its upper two-thirds, are the tibialis anterior and the long extensors of the toes; in its middle third, the anterior tibial

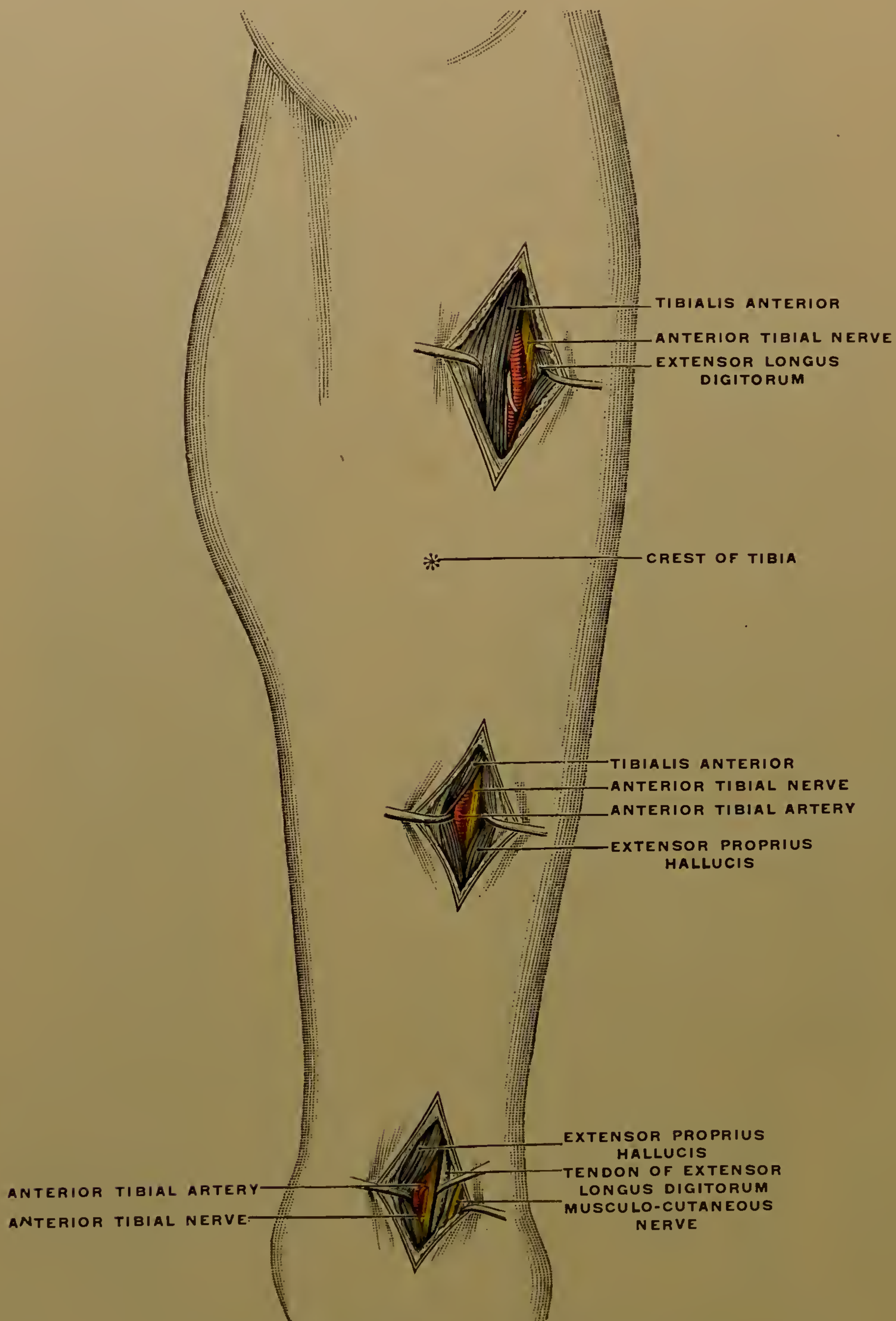


FIG. 525.—Surgical relations of the anterior tibial artery. (Kocher.)

nerve; in its lowest third, the extensor proprius hallucis and the anterior annular ligament. *Behind* are the interosseous membrane for the upper two-thirds, the tibia and ankle-joint in its lowest third. *At the mesial side* are a vena comes throughout, the tibialis anterior above, and the extensor proprius hallucis below. *At the outer side* are a vena comes for the whole length, the extensor longus digito-

run above, the extensor proprius hallucis in the middle third, and the anterior tibial nerve in the upper and lower thirds.

Variations.—The anterior tibial may be very small, or absent, its place being taken by branches from the posterior tibial or peroneal. It has been seen to

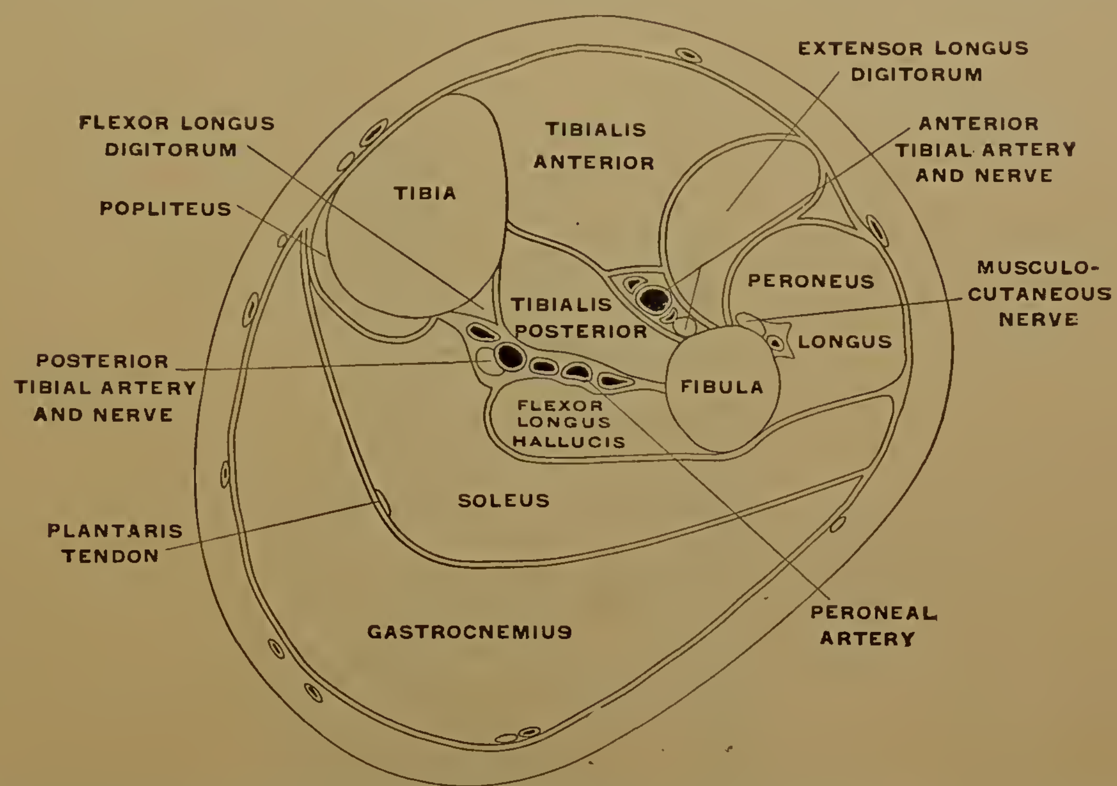


FIG. 526.—Horizontal section through upper third of right leg—upper surface of lower segment—showing anterior tibial, posterior tibial, and peroneal arteries, and their relations. (Braune.)

accompany the musculo-cutaneous nerve, winding around the fibula to reach the front of the leg.

Branches.—In its course the anterior tibial gives off the posterior tibial recurrent, the superior fibular, the anterior tibial recurrent, the muscular, the internal malleolar, and the external malleolar. The *posterior tibial recurrent* arises before

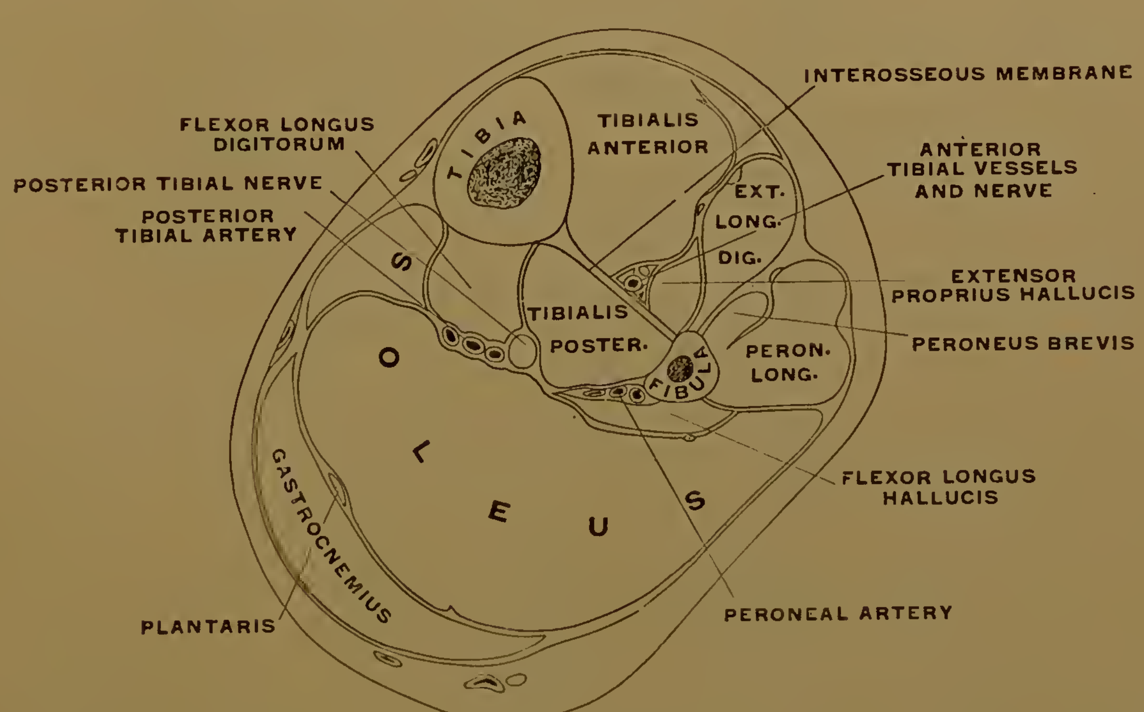


FIG. 527.—Horizontal section at middle of right leg—upper surface of lower segment. (Braune.)

the anterior tibial passes through the interosseous membrane, and runs up in front of the popliteus, supplying this muscle, the posterior ligament of the knee, and the superior tibio-fibular articulation. The *superior fibular*, given off while the anterior tibial is still behind the plane of the interosseous membrane, runs out and around the neck of the fibula to the soleus and peroneus longus. The *anterior tibial recurrent* is the first branch given off in front of the interosseous mem-

brane. It perforates the tibialis anterior, winds over the external tuberosity of the tibia, sends branches to the capsule of the knee-joint, and assists in the formation of the anastomosis around the patella. *Muscular* branches in great number are given off to the neighboring muscles and to the skin. The *internal malleolar* comes off about two inches above the end of the anterior tibial, runs behind the tibialis anterior to the inner malleolus, where it inosculates with neighboring arteries, forming a plexus. The *exterior malleolar* is given off a trifle lower than the internal, passes outward behind the extensor longus digitorum and peroneus

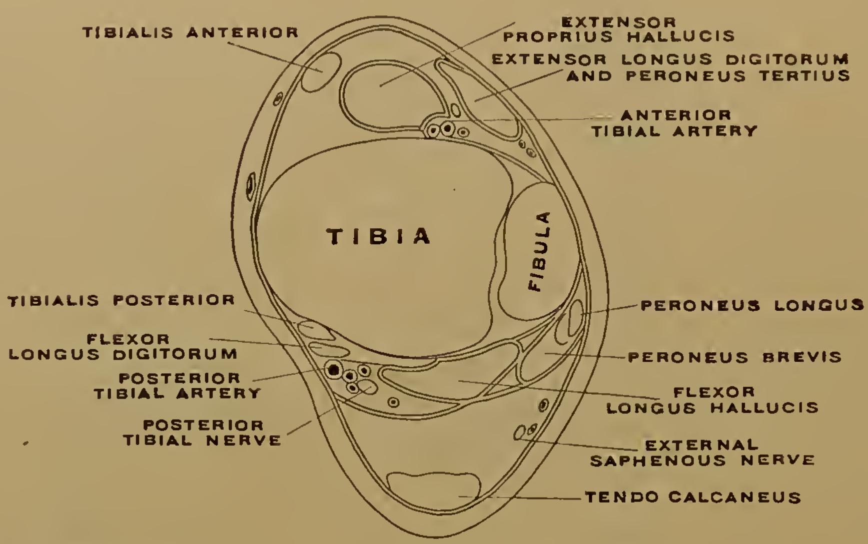


FIG. 528.—Horizontal section of right leg just above the astragalus—upper surface of lower segment. (Braune.)

tertius to the outer malleolus, and there forms, with branches of neighboring arteries, a plexus.

The Dorsalis Pedis Artery (Fig. 529) is the continuation of the anterior tibial. It begins at the bend of the ankle, and runs downward and forward to the proximal end of the first interosseous space, where it divides into the dorsalis hallucis and the deep (communicating).

Relations.—Below in succession are the astragalus, scaphoid, middle cuneiform, and their ligaments. *Above* are the anterior annular ligament in the first portion, the inner tendon of the extensor brevis digitorum at the lower end, and the fasciæ and skin elsewhere. *At the inner side* are a vena comes and the extensor proprius hallucis. *At the outer side* are a vena comes, the inner tendon of the extensor longus digitorum, and the anterior tibial nerve.

Variations.—The dorsalis pedis varies in size greatly; when large, it assists materially the plantar arteries in supplying the sole off the foot; when small, the plantar arteries may furnish a large part of the supply for the dorsum.

Branches.—The dorsalis pedis gives of the tarsal, the metatarsal, the dorsalis hallucis, and the deep (communicating). The *tarsal* passes outward over the scaphoid and cuboid, under the extensor brevis digitorum, supplying that muscle and the tarsal bones, and anastomosing freely with branches of neighboring arteries. The *metatarsal,* also called *interosseous,* given off just before the artery bifurcates, runs outward over the proximal ends of the metatarsal bones, beneath the extensor tendons, and anastomoses with the tarsal and external plantar. From it arise three *dorsal interosseous* branches, which pass forward in the second, third, and fourth interosseous spaces, receiving the posterior perforating branches of the external plantar at their proximal ends, and the anterior perforating of the same artery at the web of the toes, where each bifurcates, sending a *dorsal digital* branch to each of the digits between which it terminates, the last giving a branch also to the outer side of the little toe. The arrangement of these small digitals and their relation to the collateral digitals of the external plantar are similar to those found in homologous vessels in the hand. The *dorsalis hallucis,* otherwise known as the *first dorsalis interosseous,* one of the two terminal

branches, runs forward in the first interosseous space, and at the digital commissure gives off a branch to the mesial side of the great toe, and then bifurcates, and supplies the contiguous sides of the great and second toes. It receives the anterior perforating branch of the princeps hallucis at the web. The *deep*, often called the *communicating*, and also the *plantar digital*, one of the terminals, at the proximal extremity of the first interosseous space runs down to the end of

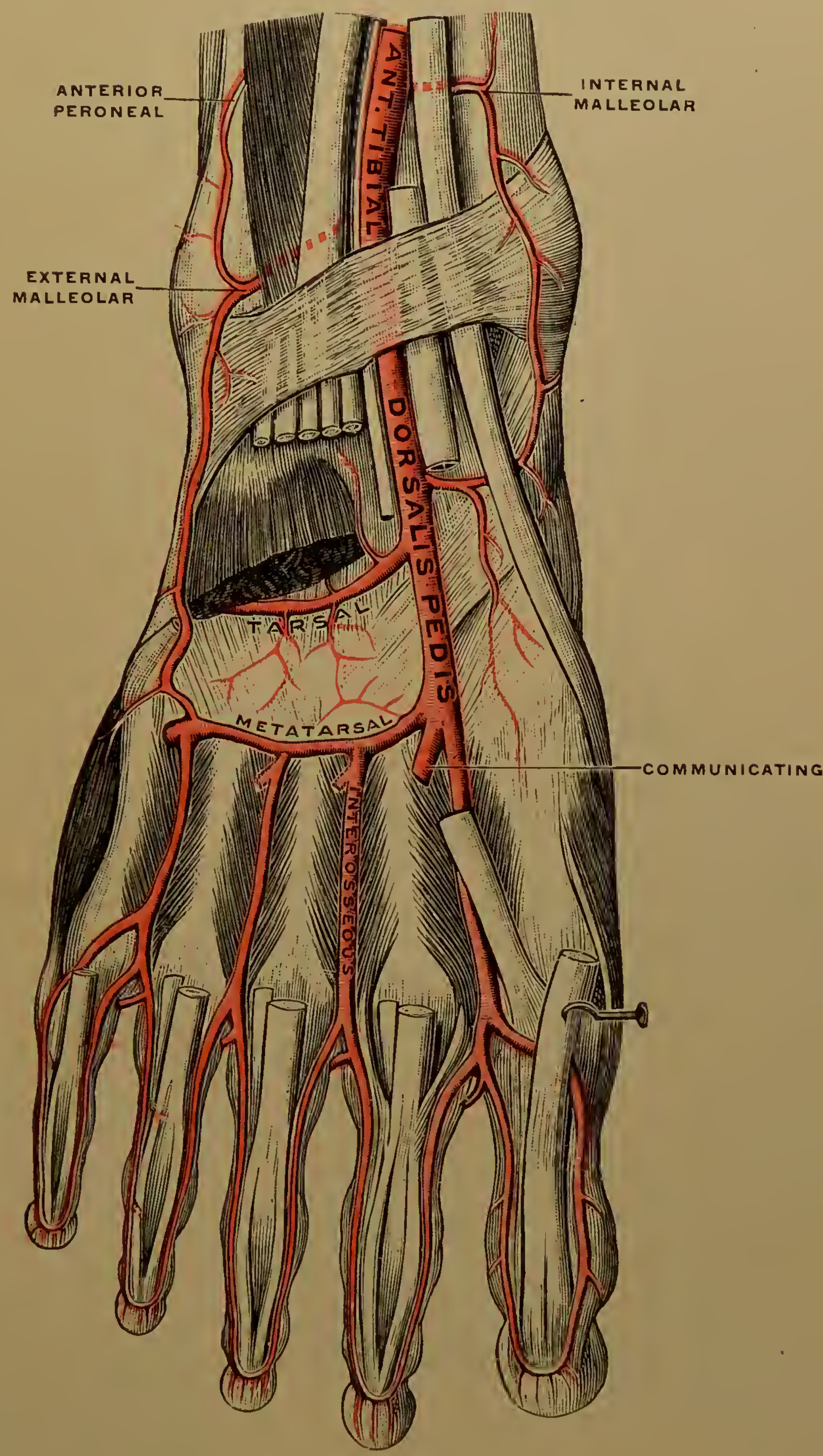


FIG. 529.—Arteries of the dorsum of the foot. Of the dorsal interosseous only the second is labelled. (Testut.)

the external plantar, and thus assists in the formation of the plantar arch. It immediately gives off the *princeps hallucis* (arteria magna hallucis), which sends a branch to the inner side of the great toe, and then runs forward in the first interosseous space to the commissure, where it behaves like the digital branches of the external plantar, giving a branch to each of the contiguous sides of the great and second toes.

THE VEINS.

By G. WOOLSEY.

THE *veins* are the vessels through which the blood is returned from the capillaries to the heart. Like the arteries, they may be divided into the *pulmonary* and the *systemic*.

THE PULMONARY VEINS.

These consist of two large, short trunks on either side, in the root of the corresponding lung (Fig. 530). They extend nearly horizontally inward and forward from the hilum of the lung to the upper part of the back of the left auricle. They lie in front of and below the corresponding pulmonary arteries, and on piercing the pericardium they are invested on their ventral aspect only by the

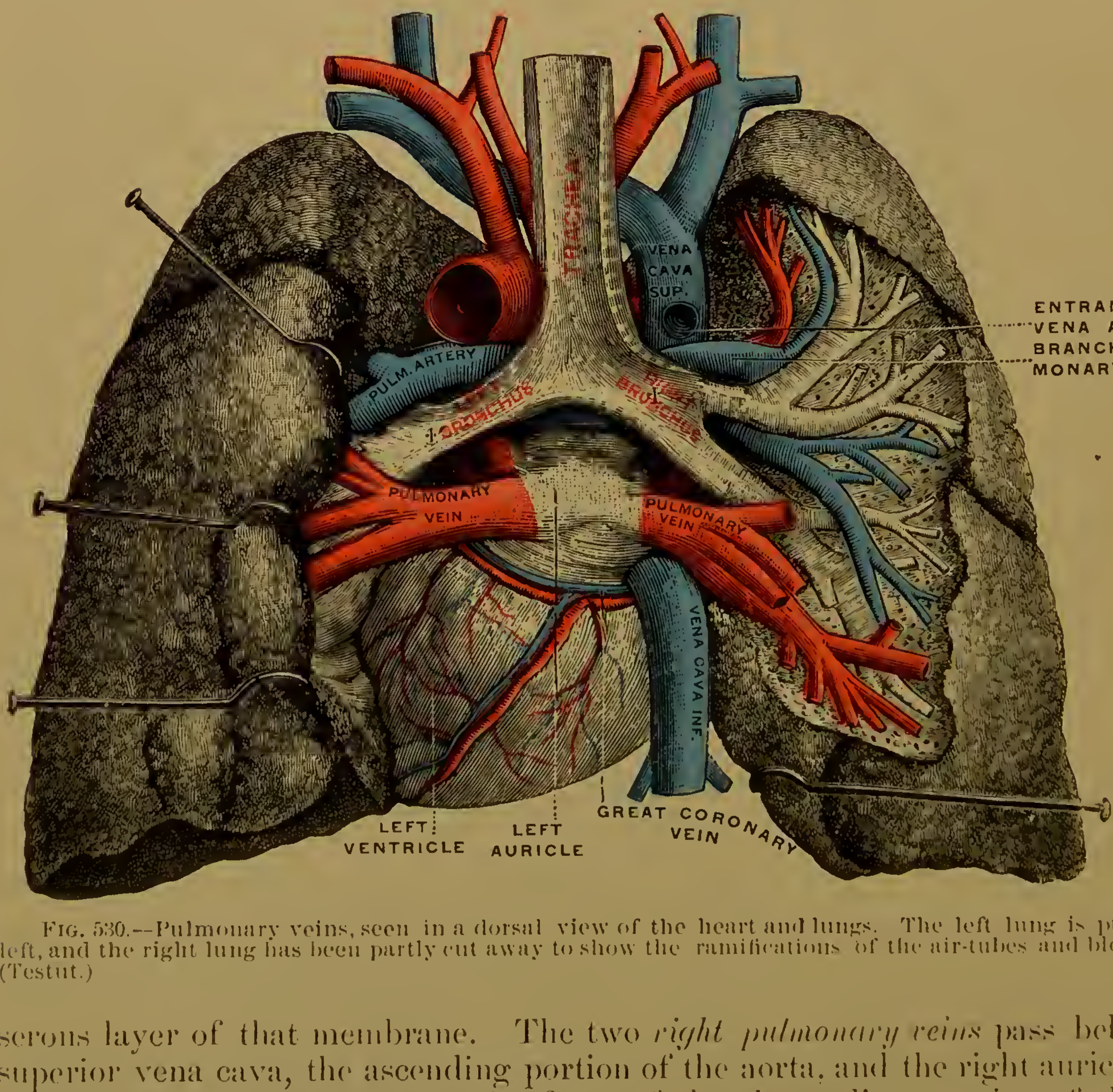


FIG. 530.—Pulmonary veins, seen in a dorsal view of the heart and lungs. The left lung is pulled to the left, and the right lung has been partly cut away to show the ramifications of the air-tubes and blood-vessels. (Testut.)

serous layer of that membrane. The two *right pulmonary veins* pass behind the superior vena cava, the ascending portion of the aorta, and the right auricle. The two *left pulmonary veins* pass in front of the descending portion of the aorta. They convey arterial blood, and have no valves.

The pulmonary veins are but little larger than the arteries they accompany. The right superior pulmonary vein commonly receives the vein from the middle lobe of the right lung, but sometimes the latter continues to the auricle separately as a third vein. The two pulmonary veins, on a side, more often on the left, sometimes unite, and terminate in a single trunk.

THE SYSTEMIC VEINS.

These convey the blood from the capillary plexuses of the rest of the body to the right auricle of the heart, which most of the veins of the heart enter by the coronary sinus, and the veins of the remainder of the body by the superior and inferior venæ cavæ. They differ from the arteries in their larger capacity, their greater number, their thinner walls, their larger and frequent anastomoses, and the presence here and there of more or less perfect valves, which prevent backward circulation. The veins from the stomach, intestines, spleen, and pancreas differ from the others in that, after joining to form a single trunk, the *portal vein*, the latter breaks up in the substance of the liver into a capillary network, from which the blood is collected by the hepatic veins, and emptied into the inferior vena cava.

The veins may be divided into *two sets*, the superficial and the deep, between which there are frequent communications. The *superficial* or *subcutaneous veins* lie between the layers of the superficial fascia, and do not usually accompany an artery. The *deep veins* usually accompany the arteries, sometimes as a single trunk, as with the larger arteries (axillary, femoral, etc.), sometimes as a frequently anastomosing pair, the *venæ comites*, one on either side of the smaller arteries (radial, tibial, etc.).

The *venous sinuses* of the cranium differ from the veins in structure. They are formed between the two layers of the dura, and lined by a continuation of the intima of the veins.

In the following pages a detailed description is necessary only for those veins which do not accompany an artery. The systemic veins are naturally divided into three groups, according as they empty into the heart through the superior or the inferior vena cava, or the coronary sinus.

THE VEINS OF THE HEART.

The *cardiac* or *coronary veins* (Fig. 531), which return the blood from the substance of the heart, accompany the arteries, but have not an exactly similar course, as the arteries start in front, while the veins empty into the coronary sinus behind.

The **Coronary Sinus** is situated in the dorsal part of the groove between the left auricle and ventricle. About an inch in length, it is covered by the muscular fibres of the auricles, and its termination in the right auricle, between the opening of the inferior vena cava and the auriculo-ventricular aperture, is guarded by the coronary or Thebesian valve. Where the cardiac veins (excepting the oblique vein) join the coronary sinus they are guarded by valves, which are wanting in the rest of their course.

The **oblique vein** of Marshall, which runs over the back part of the left auricle in the vestigial fold of the pericardium, enters the left extremity of the sinus without a valve to guard the opening. The oblique vein with the coronary sinus represents the left superior vena cava, or the left duct of Cuvier and part of the sinus venosus of the fœtus. This vein is often represented in great part by a fibrous cord.

The **Great Cardiac Vein** (anterior coronary vein) ascends from near the apex of the heart in the ventral interventricular groove to the auriculo-ventricular groove, in which it turns to the left and passes backward to terminate in the left end of the coronary sinus, which appears as the dilated continuation of this vein.

It accompanies first the anterior and then the posterior branch of the left coronary artery, and receives branches from either side of its course, one of which, ascending along the left margin of the heart (*left marginal vein*) is of some size.

The **Middle Cardiac Vein** (*posterior interventricular vein*) ascends from the apex of the heart in the dorsal interventricular groove to empty into the right extrem-

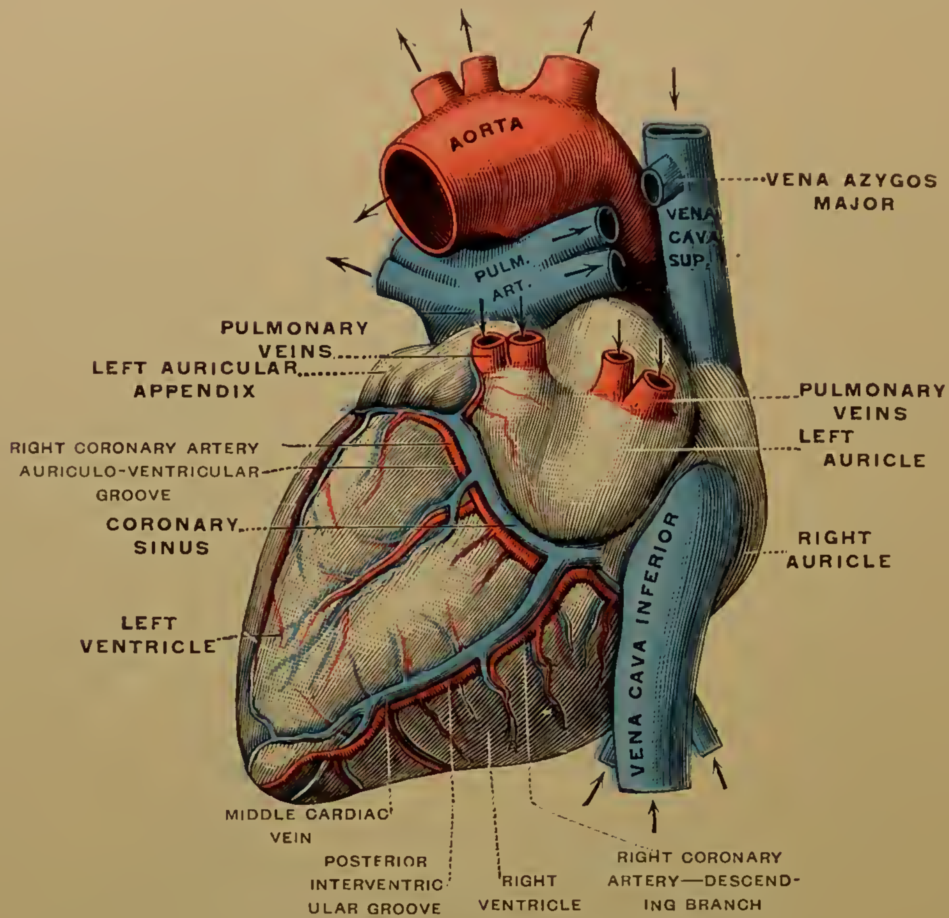


FIG. 531.—Cardiac veins, dorsal view. (Testut.)

ity of the great coronary sinus. It receives branches from the dorsal surface of both ventricles.

The **Posterior Cardiac Veins** are three or four small vessels, which ascend on the dorsal surface of the left ventricle to open along the lower border of the coronary sinus.

The **Right or Small Coronary Vein** passes along the right auriculo-ventricular groove to convey the blood from the hinder parts of the right auricle and ventricle into the right end of the coronary sinus.

The following small vessels empty directly into the heart without the intervention of the coronary sinus. The **Anterior Cardiac Veins** are two or three small vessels, which collect the blood from the ventral surface of the right ventricle, and ascend to enter the lower part of the right auricle. One larger than the others (*right marginal vein* or *vein of Galen*) runs along near the antero-inferior border of the heart. The **smallest cardiac veins** (*venæ cordis minimæ*, *Venæ Thebesii*) are numerous small veins within the substance of the heart, which open into some of the small foramina Thebesii in the right auricle. Similar veins are said to open into the other heart-cavities.

THE SUPERIOR VENA CAVA AND ITS TRIBUTARIES (Figs. 531, 533).

The *superior* (*descending*) *vena cava* is formed by the confluence of the right and left brachio-cephalic (innominate) veins behind the lower part of the junction of the first right costal cartilage with the sternum. From this point it passes nearly vertically downward, with a slight convexity to the right, for about three inches, to empty into the right auricle on a level with the third costal cartilage. Its lower inch and a half are contained within the pericardium, whose serous layer invests it, except along its hind border. It receives the blood returned

from the head, neck, upper extremities and thoracic walls. It contains no valves. *Relations.*—On its *right side* are the right lung and pleura, with the phrenic nerve between. On its *left side* lies the brachio-cephalic artery above, and the ascending portion of the aortic arch below. *In front* it is overlapped by the right pleura and lung. The root of the right lung lies *behind* it.

Its *lateral tributaries* are the great azygos vein, which enters it just before it penetrates the pericardium, and small veins from the pericardium and mediastinum.

The Brachio-cephalic Veins.

The *brachio-cephalic* or *innominate veins* return the blood from the head, neck, upper extremities, and the upper part of the thoracic walls. They are formed by the union of the subclavian and internal jugular veins, behind the sternal end of each clavicle, and unite below, opposite the lower border of the first right costal cartilage, at its junction with the sternum, to form the superior vena cava. At the angle of junction of the subclavian and jugular veins there open into the venous circulation the thoracic duct on the left side and the right lymphatic duct on the right side. There are no valves in the brachio-cephalic veins.

The **Right Brachio-cephalic Vein**, only about an inch in length, descends nearly vertically on the outer side of, and superficial to, the brachio-cephalic and the commencement of the subclavian arteries. The right lung and pleura lie on its right side and in front, with the phrenic nerve between.

The **Left Brachio-cephalic Vein**, two and a half to three inches long, passes from left to right with a slight downward inclination to join the right vein. In front of it lies the upper part of the manubrium sterni, with the lower ends of the sternal muscles, below it the arch of the aorta, and behind it the three branches of the arch, and the left phrenic and pneumogastric nerves.

Lateral Tributaries.—Each brachio-cephalic vein receives the vertebral, inferior thyroid, and internal mammary veins of its own side, and, in addition, the left vein receives the left superior intercostal vein, and small thymic, mediastinal, and pericardial branches.

Variations in the Superior Vena Cava and Brachio-cephalic Veins.—These are mostly due to a persistence of the left duct of Cuvier of the fœtus, which may form a left superior vena cava. This descends from the commencement of the left brachio-cephalic vein, in front of the aortic arch and the root of the left lung, to the heart, where it is continued in the usual position of the coronary sinus to open into the right auricle. In such cases the usual left brachio-cephalic vein may persist as a small communicating branch between the right and left superior venæ cavæ, or it may be altogether wanting. In a few cases, besides those of transposition of the viscera, the superior vena cava is found on the left side, the right brachio-cephalic vein taking a transverse course similar to that usually taken by the left.

VEINS OF THE HEAD AND NECK.

I. Veins of the Surface of the Cranium and Face (Fig. 532).

A. ANTERIOR REGION.

The *superficial veins* of the face and the fore part of the cranium and the deep veins of the face unite to form two trunks, the facial and the temporo-maxillary veins, while the occipital and posterior auricular veins collect the blood from the hind part of the scalp. Valves are generally absent in the veins of the head and neck, except at the lower end of the internal and external jugular veins.

The **Facial Vein** (*anterior facial*) collects the blood from the fore part of the face and scalp. It commences at the side of the nose, on a line with the lower margin of the orbit, as the direct continuation of the angular vein. It is less

tortuous than the facial artery, posterior to which it passes downward and outward to and around the lower border of the jaw, in front of the masseter muscle. Below the lower border of the jaw it inclines backward beneath the platysma muscle, and is joined by the anterior division of the temporo-maxillary vein below the digastric muscle. The trunk thus formed is called the *common facial vein*, and empties into the internal jugular vein near the level of the hyoid bone. A communicating branch passes downward along the ventral margin of the sterno-mastoid muscle to join the anterior jugular vein.

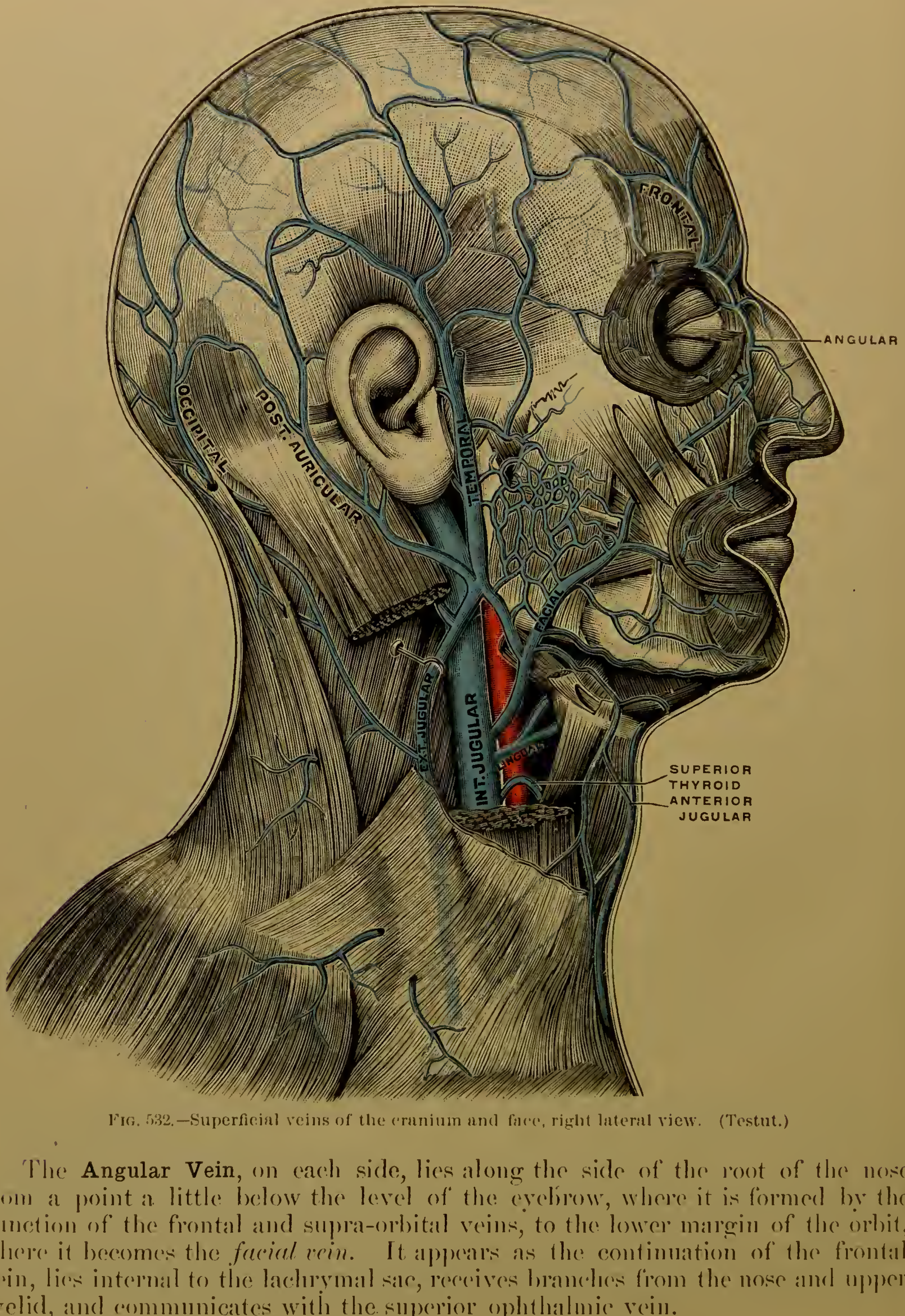


FIG. 532.—Superficial veins of the cranium and face, right lateral view. (Testut.)

The **Angular Vein**, on each side, lies along the side of the root of the nose from a point a little below the level of the eyebrow, where it is formed by the junction of the frontal and supra-orbital veins, to the lower margin of the orbit, where it becomes the *facial vein*. It appears as the continuation of the frontal vein, lies internal to the lachrymal sac, receives branches from the nose and upper eyelid, and communicates with the superior ophthalmic vein.

The **Transverse Nasal Vein** arches across the bridge of the nose, and unites the two angular veins, or the lower ends of the frontal veins.

The **Frontal Vein** is formed by branches from the forehead and the forepart of the scalp, which communicate with the anterior division of the temporal vein. These tributaries pass downward and inward to form a trunk which, connected with its fellow by cross-branches, descends nearly vertically on the side of the median line to a point a little below the inner end of the eyebrow, where it is joined by the supra-orbital vein and becomes the angular vein. The right and left frontal veins sometimes unite into a single median trunk, which bifurcates at the root of the nose into the two angular veins.

The **Supra-orbital Vein** is a smaller vessel, which collects the blood from the lower and lateral part of the forehead, upper eyelids, etc., and passes obliquely downward and inward to join with the frontal vein in forming the angular. It communicates laterally with the temporal, and dorsally with the ophthalmic vein and the frontal vein of the diploë.

The *facial vein* receives *lateral tributaries*, corresponding to the branches of the artery (*i. e.*, inferior palatine, submaxillary, submental, inferior labial, inferior and superior coronary, and lateral nasal) and in addition the following:

The **inferior palpebral veins**, two or three in number, descend from the lower eyelid, where a communication with the infra-orbital vein is established.

The **anterior internal maxillary vein** or *deep facial vein* passes downward and forward from the pterygoid plexus. It crosses the zygomatic surface of the maxilla, and opens into the facial vein beneath the zygomaticus major muscle.

Small **buccal, masseteric,** and **parotid veins** are received from the buccinator and masseter muscles and the glandula socia parotidis, respectively.

Sometimes the lingual vein joins the facial. (See lingual vein.)

The free communications between the facial vein and its tributaries and the ophthalmic vein, none of which contain valves, account for the danger of septic thrombi extending backward through the ophthalmic vein to the cavernous sinus, in case of carbuncle or other forms of inflammation near the facial vein.

B. LATERAL REGION.

The **Temporo-maxillary Vein** (*posterior facial*) is formed by the union of the temporal and maxillary veins in the substance of the parotid gland behind the neck of the mandible. It descends in the substance of the parotid gland superficial to the external carotid artery to about the angle of the jaw, where it divides into two parts. The *anterior division* passes downward and forward to join the facial vein, forming the common facial vein, while the *posterior division* is joined by the posterior auricular vein to form the external jugular vein.

The posterior auricular vein may join the temporo-maxillary vein before the bifurcation of the latter, in which case the anterior division is properly a branch of the external jugular vein.

The **Superficial Temporal Vein** collects the blood from the parietal region of the scalp, where communicating branches connect it with the supra-orbital and frontal veins in front, the veins of the opposite side above, and the posterior auricular and occipital veins behind. Its radicles unite into two trunks which, corresponding to the divisions of the artery, converge and unite in front of the ear into a single trunk.

The **Middle Temporal Vein** receives the blood from the temporal muscle, and is joined by the orbital branch, which, corresponding to the orbital branch of the temporal artery, communicates with the ophthalmic vein. Piercing the fascia near the zygoma it joins the superficial temporal to form the *common temporal vein*. The *middle temporal vein* communicates with the pterygoid plexus through the deep temporal veins, branches of that plexus corresponding to the arteries of the same name.

The **Common Temporal Vein** crosses the base of the zygoma just in front of the ear, and thence descends in the parotid gland external to the temporal artery. It

joins the internal maxillary vein opposite the neck of the jaw to form the temporo-maxillary vein.

The temporal vein also receives *anterior auricular veins* from the external ear, *transverse facial veins* from the masseter muscle, *parotid veins* from the gland, and tributaries from the plexus around the temporo-maxillary articulation, which receives a radicle from the tympanum, through the fissure of Glaser.

The **Internal Maxillary Vein** is a short vessel, which passes backward from the pterygoid plexus, accompanying the internal maxillary artery as a single or a double trunk to join with the common temporal vein in forming the temporo-maxillary vein.

The **Pterygoid Plexus** surrounds the pterygoid muscles and corresponds to the second and third portions of the internal maxillary artery, by the companion veins of whose branches it is made up. Its principal outlet is the internal maxillary vein. It also communicates in front with the facial vein, through the deep facial vein, above with the inferior ophthalmic vein and the cavernous sinus, behind with the plexus from which the middle temporal vein arises, and below with the pharyngeal plexus.

The **Posterior Auricular Vein** descends from a plexus on the lateral aspect of the scalp, which communicates with the temporal and occipital veins and with the vein of the opposite side. It is large in comparison with its companion artery, which it leaves below the ear, and inclines forward toward the angle of the jaw to join the posterior division of the temporo-maxillary vein, forming thereby the external jugular vein.

C. POSTERIOR REGION.

The **Occipital Veins** collect the blood from the hind part of the venous plexus of the scalp, and descend, as one or two trunks, with the occipital artery deeply into the neck, where they are continuous with the *deep cervical vein*. An emissary vein, passing through the mastoid foramen, connects the lateral sinus with this vein, or, in some cases, with the posterior auricular vein.

II. Veins of the Neck (Fig. 533).

The **External Jugular Vein,** formed by the union of the posterior auricular vein and the posterior division of the temporo-maxillary vein, descends nearly vertically from its commencement near the angle of the jaw to terminate in the subclavian vein opposite the middle of the clavicle. It lies beneath the platysma, and crossing the sterno-mastoid muscle obliquely it follows the posterior border of the latter in its lower half. Near the clavicle it pierces and is closely connected with the deep cervical fascia, which holds it open. It has a pair of imperfect valves at its entrance into the subclavian vein, and another an inch or two above the clavicle. The part between the valves is called the *sinus*, being often dilated. Its *lateral tributaries* are the following:

The **posterior external jugular vein.** This descends behind the sterno-mastoid muscle, from the skin and superficial muscles of the upper and back part of the neck and the lower occipital region, to terminate in the external jugular vein below its middle. It may communicate with the occipital vein.

The **transverse cervical** and **suprascapular veins** accompany their corresponding arteries, and open into the external jugular vein a little above its termination. They sometimes present a plexiform arrangement in the subclavian triangle. These veins have valves near their termination and may sometimes open directly into the subclavian vein.

The **anterior jugular vein** takes origin below the chin from small tributaries which communicate with the lower radicles of the facial vein. It descends at a variable distance from the median line to near the inner end of the clavicle, where it perforates the deep fascia and turns outward beneath the sterno-mastoid muscle to open into the lower end of the external jugular vein, or sometimes directly into

the subclavian vein. It receives a branch from the facial vein which descends along the ventral border of the sterno-mastoid muscle. A transverse branch connects the lower ends of the veins of the two sides, and others may exist higher up.

Its position behind the origin of the sterno-mastoid should be remembered in tenotomy of that muscle. It varies in size inversely with that of the external jugular vein.

The **Internal Jugular Vein** receives the blood from the cranial cavity. It begins at the enlarged *sinus* or bulb of the sigmoid sinus, which is lodged in the large dorsal compartment of the jugular foramen. After a nearly straight

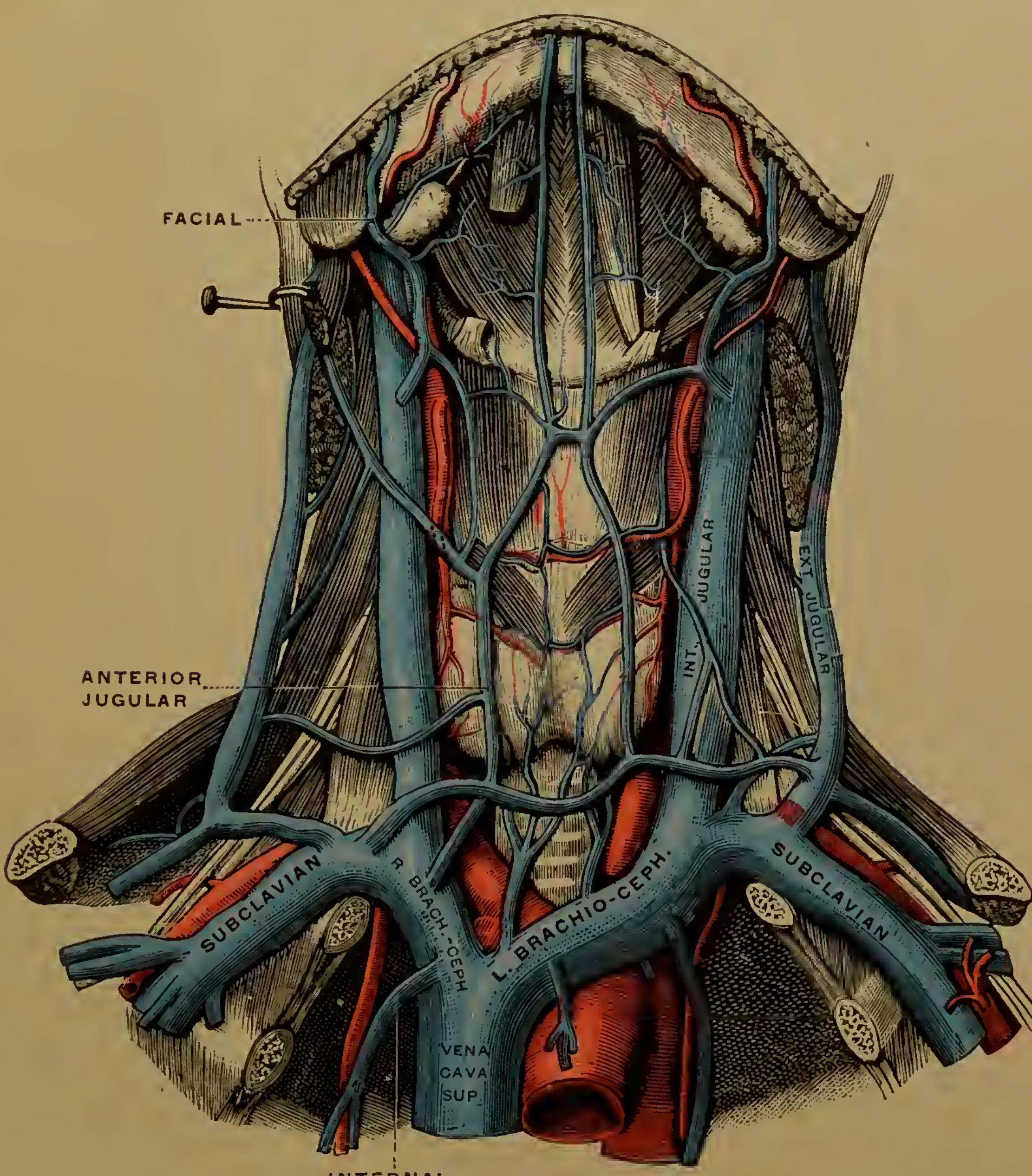


FIG. 533.—Veins of the neck and upper part of thorax, front view. (Testut.)

course it ends behind the sternal end of the clavicle, where it joins the subclavian vein to form the brachio-cephalic vein. At the base of the skull it is behind and then becomes external to the internal carotid artery. Lower down it lies external to and in the same sheath with the common carotid artery, overlapping it below, especially on the left side. A pair of imperfect valves is found about an inch above its termination. It has the following *lateral tributaries*:

The **inferior petrosal sinus** opens into the bulb or into the commencement of the internal jugular vein.

The **pharyngeal plexus**, on the outer surface of the pharynx, receives the blood from the neighboring parts, and opens into the jugular vein directly or through the common facial vein. It communicates above with the pterygoid plexus and receives branches from the soft palate and Eustachian tube.

The **lingual vein** (Fig. 534). Two small venæ comites usually accompany the lingual artery, but most of the blood is returned from the tongue by the *ranine*

vein, which starts near the tip of the tongue, and passes backward beneath the mucous membrane of its under surface. As it continues backward it is separated from the lingual artery by the hyoglossus muscle, on the outer surface of which it lies below the hypoglossal nerve. It is joined by the lingual venæ comites and by branches corresponding to the branches of the artery, and empties into the

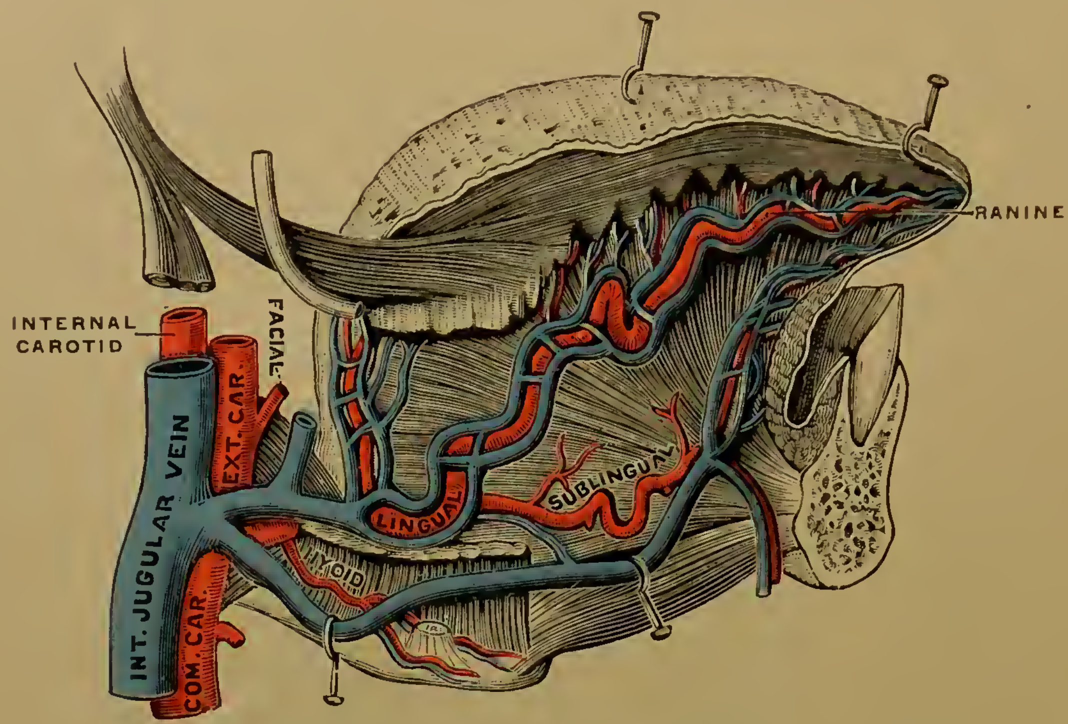


FIG. 534.—Arteries and veins of the tongue, viewed from the right side. The ranine vein is pulled downward by hooks. (Testut.)

internal jugular or the facial vein. Some of its tributaries not infrequently open separately into the internal jugular or into the facial vein.

The **common facial vein** has been described above.

The **superior thyroid vein** corresponds to the artery of the same name, and, after crossing the upper end of the common carotid artery, it empties into the internal jugular or the common facial vein. The three thyroid veins on each side communicate freely with each other and with those of the opposite side.

The **middle thyroid vein** emerges from the lower part of the lateral lobe of the thyroid body, and, after crossing the common carotid artery, empties into the internal jugular vein, a little below the level of the cricoid cartilage.

The **inferior thyroid veins** descend from the lower part of the thyroid body, one on either side of the trachea. Frequent anastomoses form a kind of plexus, from which the left vein descends to empty into the left brachio-cephalic vein, the right vein into the angle of union of the two brachio-cephalic veins, or into the lower end of the right brachio-cephalic vein, or it may join the left vein. They lie under cover of the sterno-hyoid muscles, and receive inferior laryngeal, tracheal, and œsophageal veins. They are guarded by valves at their termination. They may seriously embarrass the surgeon in performing low tracheotomy.

The **Vertebral Vein** corresponds to the cervical portion only of the vertebral artery. Commencing in the suboccipital triangle in a plexus of small veins, it accompanies the vertebral artery in a plexiform manner through the foramina of the transverse processes of the upper six cervical vertebræ. Thence as a single vessel it descends across the subclavian artery to open into the upper end of the brachio-cephalic vein, dorsally.

Tributaries.—At its upper end it communicates with the occipital, deep cervical, and intraspinal veins. It receives branches from the dorsal spinal veins of the neck, the lateral spinal veins, and the plexus on the ventral surface of the bodies of the cervical vertebræ. Near its lower end it is joined by the deep cervical and anterior vertebral veins, and usually by the first intercostal vein, which accompanies the superior intercostal artery.

The **anterior vertebral vein** descends from in front of the cervical vertebræ,

accompanying the ascending cervical artery, and receiving branches from the neighboring muscles.

The **deep cervical vein** (*posterior vertebral*) descends at the back of the neck, in company with the deep cervical artery, from the suboccipital plexus, through which it receives the occipital vein. Below the transverse process of the seventh cervical vertebra it turns forward to empty into the lower end of the vertebral vein.

III. The Veins of the Diploe (Fig. 535).

These are contained in a plexus of bony channels in the cancellous tissue of the bones of the roof and sides of the skull. They are arranged in four groups,

FIG. 535.—Veins of the diploë. The outer table of cranial bones is removed. (Testut.)

whose trunks descend to communicate with the meningeal veins, the sinuses of the dura and the veins of the scalp. They are named from their position.

The **frontal veins** of the diploë open into the supra-orbital vein at the bottom of the supra-orbital notch or foramen.

The **anterior temporal veins** of the diploë open into the deep temporal veins through an opening in the great wing of the sphenoid.

The **posterior temporal veins** of the diploë join the lateral sinus through the mastoid foramen or an opening at the dorso-inferior angle of the parietal bone.

The **occipital veins** of the diploë open into the occipital vein externally, or into the lateral sinus internally.

In fœtal life the veins of each bone are distinct, but they anastomose freely after the bones come together.

IV. The Venous Sinuses of the Cranium (Figs. 536, 537).

These are venous channels situated between the two layers of the dura, and lined by a continuation of the lining membrane of the veins. They collect the blood from the brain, orbit, and eyeball, and some of that from the meninges and diploë, and empty into the internal jugular vein. They communicate with the superficial veins by means of the *emissary veins*, passing through certain foramina in the cranium. They may be divided into two groups, the one situated above and behind, the other at the base of the skull; the former including the superior and inferior longitudinal, the straight, the lateral, and the occipital sinuses, while the latter embraces the cavernous, the circular, the basilar, and the inferior and superior petrosal sinuses.

The **Superior Longitudinal Sinus** extends in the median line along the attached

margin of the falx cerebri, increasing constantly in size, from the foramen cæcum in front to the internal occipital protuberance behind, where, turning sharply to one side, usually the right, it is continuous with the lateral sinus. Its triangular lumen is crossed by a number of fibrous bands (the cords of Willis), and projecting into it at intervals are the Pacchionian bodies. It receives the superior cerebral veins, which enter it mostly from behind forward (*i. e.*, against the blood-stream). It often communicates through the parietal foramen with the temporal veins of the scalp, and regularly in early life through the foramen cæcum with the veins of the nose. On approaching the internal occipital protuberance it inclines slightly to one side, usually the right, and presents a dilatation, the *torcular Herophili* ("the wine-press of Herophilus"), which is lodged in a depression on the side of the internal occipital protuberance. The torcular usually receives the occipital sinus, and gives a cross-branch to the straight sinus, where the latter bends into the opposite lateral sinus.

The **Inferior Longitudinal Sinus** is a small vessel of cylindrical form, which occupies the dorsal half or more of the lower border of the falx cerebri. It receives some tributaries from the falx and the median surface of the brain, and terminates in the straight sinus.

The **Straight Sinus**, triangular on section, extends downward and backward along the line of junction of the falx cerebri and the tentorium cerebelli, to the internal occipital protuberance, where it bends sharply to the side, usually to the

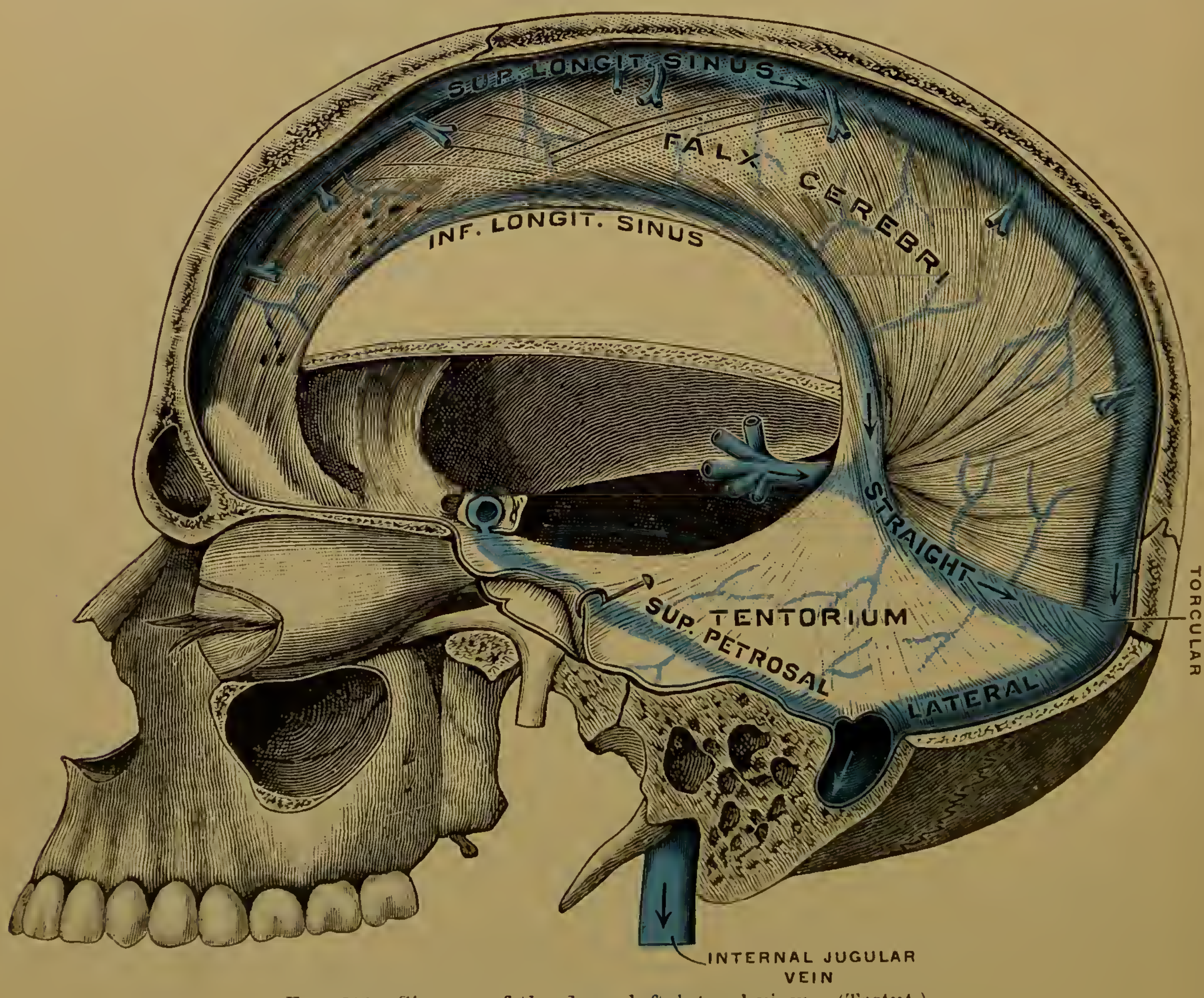


FIG. 536.—Sinuses of the dura, left lateral view. (Testut.)

left, and is continued into the lateral sinus, being connected by a cross-branch with the torcular. It is formed in front, at the margin of the tentorium, by the union of the inferior longitudinal sinus with the great vein of Galen from the interior of the brain.

The **Lateral Sinuses** commence at the internal occipital protuberance, and end at the jugular foramina in the bulbs or sinuses which are continuous with the internal

jugular veins. Each sinus passes at first nearly horizontally outward, with a slight convexity upward, in the groove on the occipital bone and the dorso-inferior angle of the parietal bone, along the attachment of the tentorium cerebelli. Thence it curves downward and inward in the groove on the inner surface of the mastoid, leaving the tentorium after receiving the superior petrosal sinus (and, when present, the petro-squamous sinus). Finally it curves forward onto the jugular process of the occipital bone to the jugular foramen. That part of the sinus on the mastoid bone and the jugular process of the occipital is called the *sigmoid sinus*, from its S-shaped course. This part is semicylindrical in shape, communicates with the occipital sinus through the marginal sinus, and with the occipital and vertebral veins by means of emissary veins passing through the mastoid and posterior condylar foramina respectively. The lateral sinus receives veins from the temporal lobe of the brain, from the upper and lower surfaces of the cerebellum, and from the medulla, pons, and diploë. The right lateral sinus is considerably larger than the left, except in cases where the superior longitudinal sinus is continued into the left sinus.

The *position* of the lateral sinus may be represented on the exterior of the skull by a line curved slightly upward from the external occipital protuberance to

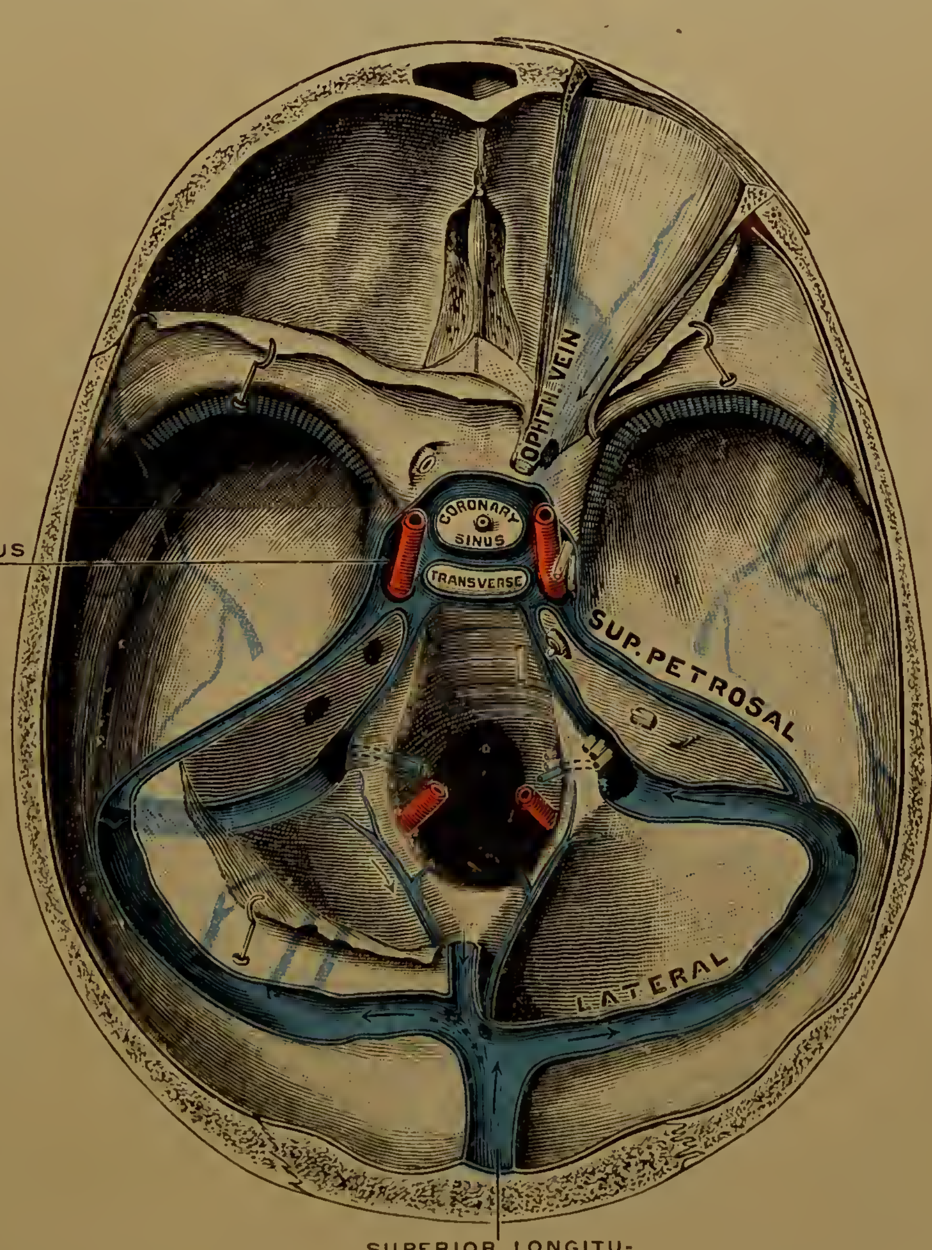


FIG. 537.—Sinuses of the dura at the base of the cranium. (Testut.)

the base of the mastoid process, and thence its sigmoid portion bends downward and inward toward the tip of the process, making a forward bend or knee which extends to within half an inch or less of the upper part of the bony external auditory meatus.

The **Occipital Sinus** ascends mesially, along the line of attachment of the falx cerebelli to the occipital bone, from the foramen magnum in front to the torcular behind. Its tributaries pass around one or both sides of the foramen magnum, as *marginal sinuses*, one or both of which communicate with the lower end of the lateral

sinuses. It communicates with the posterior spinal veins, and receives inferior cerebellar veins. The marginal sinuses occasionally end in two parallel occipital sinuses.

The **Cavernous Sinuses** (Fig. 538) lie between the layers of the dura, one on each side of the body of the sphenoid bone. They extend from the sphenoidal fissure in front, where they receive and are practically continuous with the ophthalmic veins, to the apex of the petrous bone behind, where they end in the petrosal sinuses. The two are connected across the middle line in front, behind, and often below the pituitary body, by vessels which are called *anterior, posterior,* and *inferior intercavernous sinuses,* and which together form the *circular* or *coronary sinus.* Each cavernous sinus is bridged across by fibrous bands, so that its cavity resembles cavernous tissue, from which it derives its name. In the outer wall are the third, fourth, and ophthalmic divisions of the fifth nerve, which lie in the order named from above downward and from within outward. The internal carotid artery and the sixth nerve also pass along in the sinus separated from its lumen

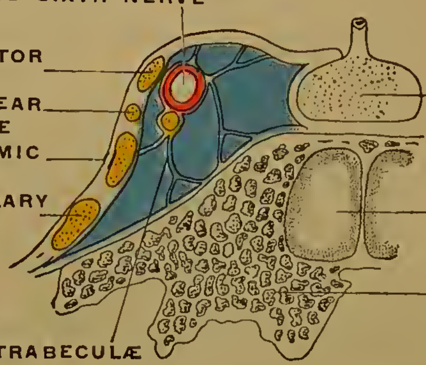


FIG. 538.—Cavernous sinus, as shown by transverse section through the middle of the sella turcica. (W. Keiller.)

by its epithelial lining only. This sinus receives some inferior cerebral veins, and communicates with the pterygoid plexus through the ophthalmic vein, and through a slender vein passing through the foramen of Vesalius and another through the foramen ovale. It also communicates with the pharnygeal plexus and the internal jugular vein, by branches passing through the foramen lacerum medium and the carotid canal respectively. This sinus also receives in front the small *spheno-parietal sinus,* which, communicating with the middle meningeal veins, near the apex of the small wing of the sphenoid, runs inward on the under surface of this bony process.

The **Superior Petrosal Sinus** extends backward as a narrow channel in the attached margin of the tentorium cerebelli, along the groove in the upper border of the petrous bone, from the cavernous sinus in front to the lateral sinus behind. It receives veins from the temporal lobe of the brain, the cerebellum, and the tympanum.

The **Inferior Petrosal Sinus**, larger but shorter than the superior, runs backward and downward in a groove along the petro-occipital suture, from the hind end of the cavernous sinus in front to the upper end of the internal jugular vein, which it reaches after passing through the forward compartment of the jugular foramen. It receives inferior cerebellar veins, and veins from the oblongata, pons, and internal ear.

The **Transverse** or **Basilar Sinus** (*basilar plexus*). Connecting the two inferior petrosal sinuses across the median line is a plexus of veins, lying in the dura on the basilar process of the occipital bone. It communicates below with the anterior spinal veins.

The **petro-squamous sinus** is sometimes found in the adult in a groove along the petro-squamous suture, opening behind into the lateral sinus, where the latter bends downward onto the mastoid bone. It represents the remains of an early fœtal condition, in which the lateral sinuses are continued forward in this course, and then through a foramen in the squamous bone, to open into the primitive (afterward the external) jugular vein, before the development of the internal jugular vein.

The Ophthalmic Veins.

Commencing near the inner canthus of the eyelid, where it communicates freely with the angular, frontal, and supra-orbital veins, the principal or *Superior Ophthalmic Vein* extends backward and inward to the inner end of the sphenoidal fissure, where it joins the inferior ophthalmic vein to form the short, thick common ophthalmic trunk. The latter passes through the fissure, to end in the fore part of the cavernous sinus. In the orbit the superior ophthalmic vein crosses above the optic nerve, a little anterior to the artery, and receives tributaries similar to the branches of the artery.

The Inferior Ophthalmic Vein.—Formed by the union of some inferior muscular branches with the lower posterior ciliary branches, this smaller ophthalmic vein runs backward in the floor of the orbit, beneath the optic nerve. It terminates by joining the superior ophthalmic vein to form the short *common ophthalmic trunk*, or by opening separately into the cavernous sinus. A branch, and occasionally the entire vein, descends through the spheno-maxillary fissure to join the pterygoid process.

As the ophthalmic veins have no valves, the blood, under certain conditions, may flow from behind forward into the angular vein or its branches, and thus obviate pressure in the veins of the retina, when the cavernous sinus is obstructed.

The Emissary Veins.

These pass through foramina in the skull to connect the cranial sinuses with the surface veins of the scalp. The blood-current may be in one or the other direction under varying conditions of intracranial pressure. They may serve as the channels along which infection is carried from the surface to the interior of the cranium. The following communications occur through emissary veins. (*A*) The *longitudinal sinus* communicates with the temporal veins through one or both parietal foramina, when present, and, in the child, with the veins of the nose through the foramen cæcum. (*B*) The *lateral sinus* is connected with the occipital (or posterior auricular) vein through the mastoid foramen, and sometimes with the vertebral vein through the posterior condylar foramen. (*C*) The *cavernous sinus* communicates with the pterygoid plexus through the foramen of Vesalius and the foramen ovale, as well as through the inferior ophthalmic vein; with the pharyngeal plexus through the foramen lacerum medium; and with the internal jugular vein by the carotid plexus through the carotid canal. (*D*) The *occipital sinus*, through the marginal sinuses, may communicate with the vertebral and extraspinal veins by way of the anterior condylar foramen. (*E*) A small vein occasionally passes to the *torcular* through a foramen in the occipital bone, near the external occipital protuberance.

The Veins of the Brain.

These open into the cranial sinuses and have several peculiarities.

THE VEINS OF THE CEREBRUM.

These have very thin walls owing to the absence of muscular tissue, and contain no valves. They are more numerous than the arteries, and, for the most part, do not accompany them. Those veins opening into the superior longitudinal sinus enter it against its current, after ascending with the arteries, instead of descending with the ascending arteries.

The cerebral veins may be divided, like the arteries, into a *superficial set* on the surface, which anastomose freely together, and a *deep set*, which emerge from the ventricles by the transverse fissure.

The **Superficial Veins** run in the fissures, and occasionally across the gyri, and are subdivided into superior and inferior groups.

The **superior cerebral veins**, eight to twelve in number on each side, pass inward and slightly forward from the upper surface of the cerebrum. After

joining others from the mesial surface, they open into the longitudinal sinus, running for some distance in its walls.

The **inferior cerebral veins** collect the blood from the outer and under surfaces of the cerebrum, and open into the cavernous, superior petrosal, or lateral sinuses, according to their position. The *Middle Cerebral Vein* is one of large size, which overlies the fissure of Sylvius, receiving branches from adjoining lobes, and ends in the cavernous sinus. The *Great Anastomotic Vein* of Trolard, by anastomosing on the parietal lobe with a branch of the middle cerebral vein and with one of the superior veins, establishes a communication between the cavernous and the superior longitudinal sinuses. Similarly the *Posterior Anastomotic Vein* of Lubbe connects the cavernous and lateral sinuses, by anastomosing with the middle cerebral vein on the temporal lobe.

The **Deep Cerebral Veins** join to form two trunks, the *Veins of Galen*, which, beginning near the porta (foramen of Monro), by the union of the choroid vein and the vein of the corpus striatum on each side, pass back, parallel with and near each other, between the layers of the velum interpositum. Beneath the splenium of the corpus callosum they pass out of the brain at the great transverse fissure, after joining to form a single trunk (vena magna Galeni), which ascends to enter the straight sinus.

The choroid vein runs forward and upward along the outer border of the choroid plexus (the blood of which it returns) to its fore part where, near the porta (foramen of Monro), it joins the vein of the corpus striatum. The latter runs forward in the groove between the corpus striatum and the optic thalamus, receiving branches from them and the neighboring parts. It joins the choroid vein as above described.

Each vein of Galen, just before it joins its fellow, receives the basilar vein of that side which, formed by the union of the anterior cerebral vein, the deep Sylvian vein, and the inferior striate vein, passes backward and around the crus cerebri to its termination. The *anterior cerebral vein* runs from the genu of the corpus callosum, the *deep Sylvian veins* from the insula and adjacent parts (communicating with the middle cerebral vein), and the *inferior striate vein* descends through the anterior perforated space from the corpus striatum.

THE VEINS OF THE CEREBELLUM.

These are divided into two sets, superior and inferior, according to their position. Of the *superior cerebellar veins* some run inward and upward to the straight sinus and the great vein of Galen, others run outward to the superior petrosal and lateral sinuses. The *inferior cerebellar veins* are larger than the superior, and some of them together with the veins of the oblongata and pons, run outward and forward to the inferior petrosal and lateral sinuses, while others pass backward to the occipital sinus.

THE VEINS OF THE UPPER EXTREMITY.

Two sets of veins are distinguished in the extremities, *superficial* and *deep*, the latter of which accompany the arteries, while the superficial set are larger, return more of the blood, and lie in the subcutaneous areolar tissue. The two sets communicate at frequent intervals. Valves are numerous in both sets, but more so in the deep veins, and are regularly found where a radicle joins a trunk, or the deep veins join the superficial.

The Superficial Veins of the Upper Extremity (Figs. 539, 540).

These commence in two plexuses, viz., a large *plexus on the dorsum of the hand*, which receives the digital veins from the fingers, and is sometimes subdivided into two parts, a radial and an ulnar; and a smaller *plexus on the front*

of the wrist, which receives a few branches from the palm and the thumb. The superficial veins of the forearm communicate freely with one another.

The **Radial Vein**, commencing in the radial side of the dorsal plexus runs up the radial side of the forearm to a little above the bend of the elbow, where, on the outer side of the biceps-tendon, it joins the median cephalic vein to form the cephalic vein. On the hand it communicates with the deep veins of the palmar arch, and along its course it receives many superficial tributaries.

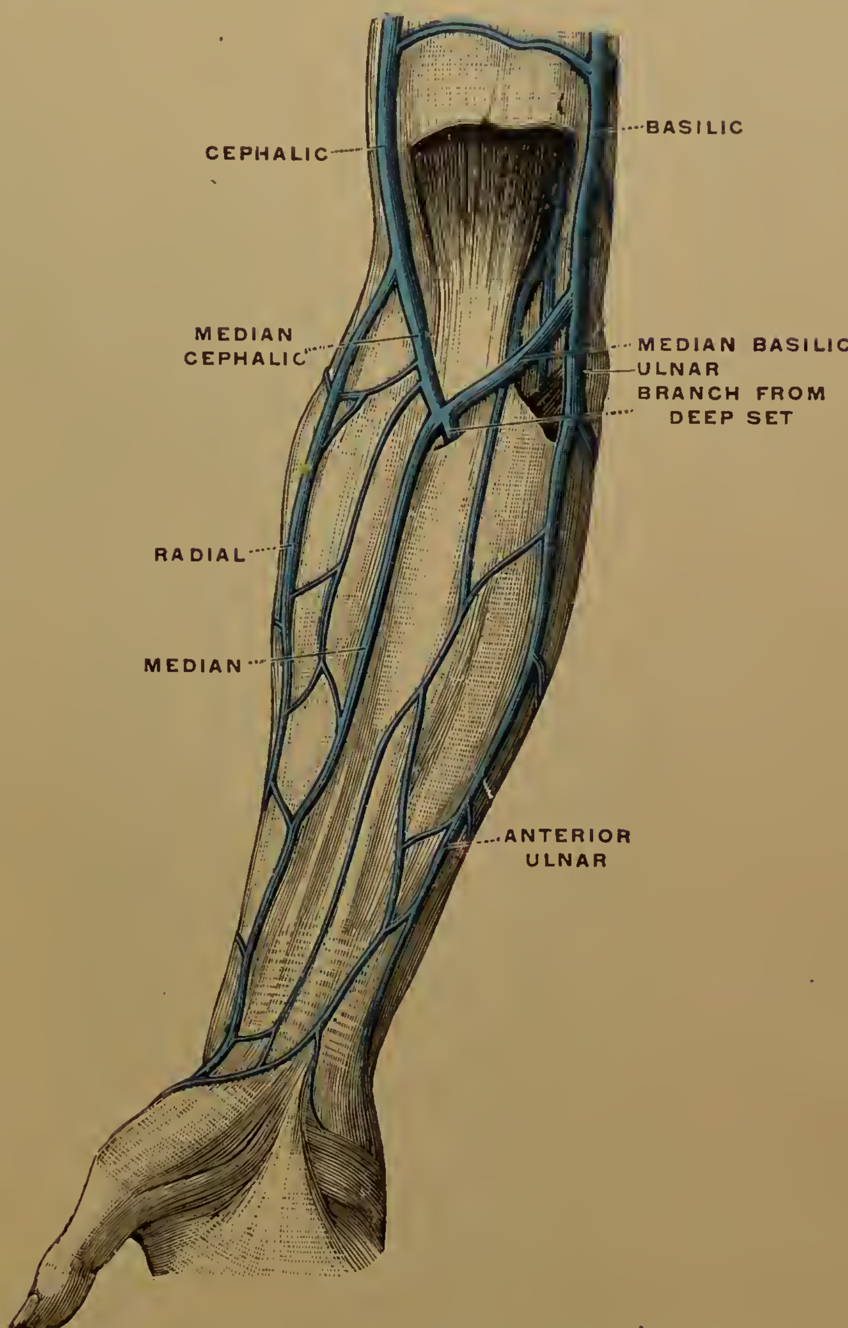


FIG. 539.—Superficial veins of front of forearm and lower part of arm. (Testut.)

The **Posterior Ulnar Vein** begins in the ulnar side of the dorsal plexus, and, after communicating with the deep palmar veins, it extends upward along the dorsal aspect of the ulnar side of the forearm, and near the bend of the elbow usually receives the anterior ulnar vein.

The **Anterior Ulnar Vein** is smaller than the foregoing, which it joins near the bend of the elbow, except rarely, when it enters the median basilic vein separately. It ascends from the wrist along the ulnar side of the front of the forearm.

The **Common Ulnar Vein** is formed by the union of the anterior and posterior ulnar veins just below the internal condyle of the humerus. After a short course it joins the median basilic, and thus forms the basilic vein.

The **Median Vein** ascends along the front of the forearm from the plexus on the front of the wrist to the bend of the elbow, where, after receiving the *deep median vein* from the deep set of veins, it immediately bifurcates into the median basilic and the median cephalic veins.

The **Median Basilic Vein**, the larger of the two divisions, is directed upward and inward to the groove internal to the biceps, where it forms the basilic vein by joining the common ulnar trunk or one of the ulnar veins. It crosses the brachial artery, from which it is separated by the fascial tendon of insertion of the biceps; hence in venesection, in which this vein was the one commonly chosen, on account of its size, constancy, and accessibility, the artery was sometimes punctured, leading to arterio-venous aneurism, etc. Branches of the internal cutaneous nerve cross in front of and behind it.

The **Median Cephalic Vein** runs upward and outward in the groove between the biceps and brachio-radialis muscles to form the cephalic vein, by uniting with the radial vein just above the bend of the elbow. The musculo-cutaneous nerve passes beneath it.

The **Basilic Vein** ascends in the groove, on the inner side of the biceps, a little internal to the course of the brachial artery. Perforating the deep fascia below the middle of the arm, it ends by joining the inner vena comes of the brachial artery to form the axillary vein.

The **Cephalic Vein**, the smaller of the veins of the arm, ascends in the groove external to the biceps and then in the interval between the deltoid and pectoralis major muscles to a little below the clavicle, where it perforates the costo-coracoid

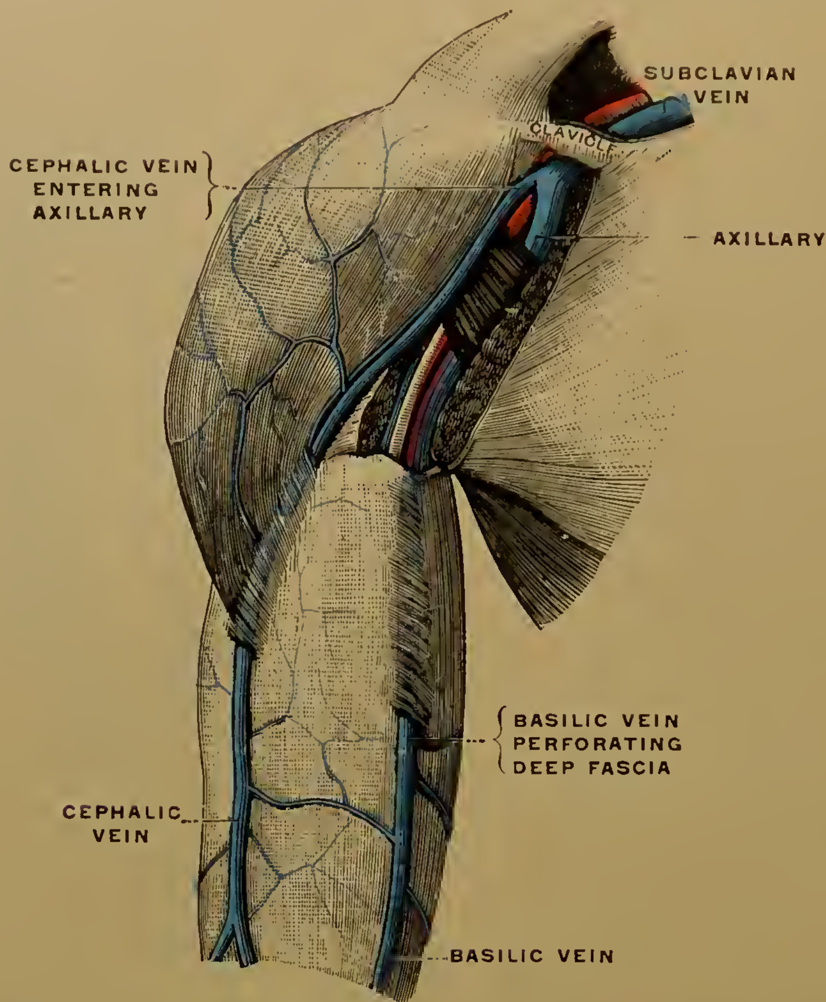


FIG. 540.—Superficial veins of front of arm and shoulder. (Testut.)

membrane, and ends in the axillary vein, after crossing the first portion of the axillary artery. Sometimes a branch, and rarely the entire vein, crosses over the clavicle to end in the external jugular vein.

The Deep Veins of the Upper Extremity.

The **Axillary Vein.**—The arteries below the axillary are accompanied by two *venæ comites* ("companion veins") with frequent cross-branches. They communicate with the superficial veins, especially in the hand and at the elbow. Near the lower border of the teres major or the subscapularis muscle, the inner brachial vena comes, and joins the basilic vein to form the single *Axillary Vein.* This accompanies the axillary artery, lying to its inner side, and ends at the outer border of the first rib in the subclavian vein. It has the same relations as the artery. It collects all the blood of the upper extremity, receiving the cephalic vein and the radicles which correspond to the branches of the axillary artery.

The **Subclavian Vein** continues the axillary vein from the outer border of the first rib to the sterno-clavicular articulation, where it ends in the brachio-cephalic vein. It lies in front of and at a somewhat lower level than the subclavian artery, from which it is separated by the scalenus anterior muscle and the phrenic nerve. It lies in the groove on the first rib in front of that for the artery. Close to the outer border of the sterno-mastoid muscle the external jugular vein empties into it, and just external to this point the vein is provided with a pair of valves.

THE VEINS OF THE THORACIC WALL.

The **Internal Mammary Veins** accompany each internal mammary artery and its branches in anastomosing pairs, which unite into a single trunk a short distance below their termination in the lower part of the brachio-cephalic vein.

The Superior Intercostal Veins.—The veins from the two to four intercostal spaces below the first join together to form a short trunk, which on the *right side* descends to empty into the upper part of the great azygos vein, and on the *left side* ascends across the arch of the aorta to empty into the left brachio-cephalic vein. The left superior intercostal vein communicates inferiorly with the left upper azygos vein, and sometimes receives the left bronchial vein. It is often connected with the oblique vein of Marshall by a fibrous cord, traceable through the vestigial fold of the pericardium and representing the left duct of Cuvier. The veins of the upper intercostal space, or sometimes the upper two intercostal spaces, ascend to join the vertebral or brachio-cephalic vein of the corresponding side.

THE AZYGOS VEINS (Fig. 541).

The **Azygos Veins,** developed from the primitive cardinal veins, form an anastomosis between the inferior and superior venæ cavæ, which is of importance in obstruction of the inferior vena cava. They receive the venous blood from the greater part of the dorsal and lateral thoracic walls. The azygos veins are three in number, and lie on the sides of the front of the vertebral bodies.

The **Right** or **Great Azygos Vein** (*vena azygos major*) commences in the abdomen as an upward continuation of the ascending lumbar vein, which communicates with the common iliac vein, and is often connected with the inferior vena cava and the renal vein. It ascends through the aortic opening of the diaphragm on the right of the aorta and the thoracic duct, in which position it continues upward in the posterior mediastinum in front of the right intercostal arteries, grooving the dorsal border of the right pleura. Opposite the lower end of the fourth thoracic vertebra it bends forward over the root of the right lung, to empty into the superior vena cava at a point just above where the latter pierces the pericardium.

Fig. 541.—Azygos and intercostal veins. (Testut.)

Tributaries.—It recieves (1) the right subcostal vein; (2) the seven or eight lower right intercostal veins; (3) the right superior intercostal vein; (4) the right bronchial veins; (5, 6) the left lower and the left upper azygos veins, and some small (7) œsophageal; (8) pericardial; and (9) mediastinal veins.

The **Left Lower** or **Small Azygos Vein** (*vena hemiazygos, vena azygos minor*) commences in the abdomen on the left side, in a manner similar to the great azygos on the right side, the branch from the renal vein being more constant, and sometimes the principal source. It ascends through the left crus of the diaphragm, and in the posterior mediastinum it lies in front of the left intercostal arteries as far as the eighth thoracic vertebra, where it crosses behind the thoracic aorta and thoracic duct to join the great azygos vein.

Tributaries.—It receives (1) the left subcostal vein below the diaphragm; and above it (2) the lower four left intercostal veins; (3) the left upper azygos (sometimes); and some small (4) œsophageal; and (5) mediastinal veins.

The **Left Upper Azygos Vein** (*vena hemiazygos accessoria*) varies in size with that of the left superior intercostal and the left lower azygos veins, between which it is placed. It receives two or three intercostal veins. It connects above with the superior intercostal vein, and opens below into the left lower azygos vein, or, crossing the sixth or seventh thoracic vertebra, ends separately in the great azygos vein. It often receives the left bronchial vein. It is quite variable and often absent, and then its radicles, the fifth, sixth, and seventh intercostal veins, open directly into the great azygos vein.

The **Intercostal Veins** accompany the arteries as a single trunk, lying above them. They receive large dorsal branches from the muscles of the back, the dorsal spinal plexus, and the spinal canal. They are eleven in number, one for each intercostal space, the lowest thoracic vein being called the *subcostal vein*, from its position. They terminate variously in different subjects and on the two sides. (See azygos, superior intercostal, and vertebral veins.)

The **Bronchial Veins** accompany the bronchial arteries, only part of whose blood they return, that distributed to the smaller bronchi entering the pulmonary veins. They pass out at the back of the root of the lung, and enter the upper end of the vena azygos major on the right side, and the left upper azygos or the left superior intercostal vein on the left side.

VEINS OF THE SPINE (Figs. 542, 543).

These form complicated plexuses, situated without and within the spinal canal and on the spinal cord, which communicate with one another and with the veins of the neck and trunk. They contain no valves and may be described in groups as follows:

I. **Extra-spinal Veins.**—The *Dorsal Spinal Veins* form a plexus over the laminæ and adjacent processes of the vertebræ, where they receive tributaries from the skin and muscles of the back, the larger of which run forward along the interspinous ligaments. They communicate with the posterior longitudinal spinal veins by branches perforating the ligamenta subflava, and open laterally into the vertebral or the dorsal branches of the intercostal and lumbar veins, according to the region, by branches passing forward between the transverse processes.

II. The **Veins of the Vertebral Bodies** (*venæ basis vertebrarum*) occupy horizontal bony channels in the vertebral bodies and communicate with the veins in front of and at the sides of them. They open behind, through the large single or double foramen on the dorsal surface of the bodies of the vertebræ, into the transverse connecting branches of the anterior longitudinal spinal veins.

III. **Intra-spinal Veins.**—(A) The *Meningo-rachidian Veins* are those within the spinal canal between the dura and the walls of the canal.

The *Anterior Longitudinal Spinal Veins*, large and plexiform, extend the entire length of the spinal canal behind the bodies of the vertebræ, one on either side of the posterior common ligament. Opposite the bodies of the vertebræ they are dilated and communicate with each other by transverse trunks, placed between the posterior common ligament and the body of each vertebra, which receive the veins of the vertebral bodies. Opposite the intervertebral discs they

are constricted, and send lateral branches through the intervertebral foramina to join the vertebral, intercostal, lumbar, or sacral veins, according to the region. They communicate with the basilar plexus above, and with the posterior longitudinal spinal veins throughout the spinal canal. Together with the posterior spinal veins and the marginal part of the occipital sinus they form a venous ring around the foramen magnum.

The *Posterior Longitudinal Spinal Veins,* smaller than the foregoing, are situated one on each side at the back of the spinal canal, and extend throughout

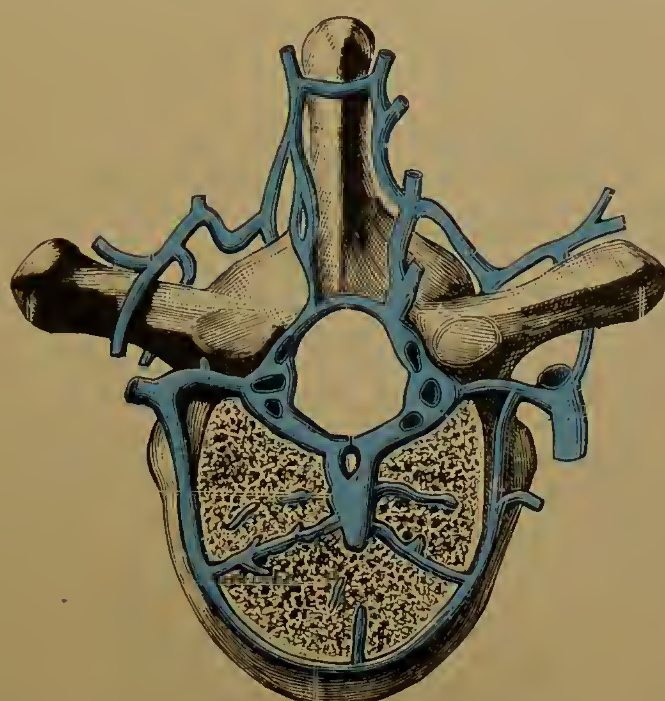


FIG. 542.—Veins of the spine, seen in a transverse horizontal section of a thoracic vertebra. (Testut.)

its entire length. They communicate with one another, by frequent transverse branches in front of the neural arches, with the dorsal spinal veins through the ligamenta subflava, with the anterior longitudinal spinal veins by lateral branches, and superiorly with the occipital sinus. Lateral branches also pass out through the intervertebral foramina to join those from the anterior longitudinal spinal veins.

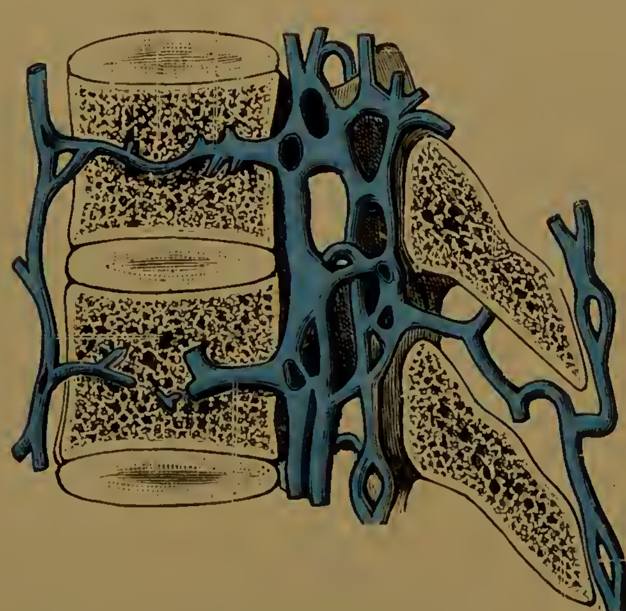


FIG. 543.—Veins of the spine, seen in a sagittal section of two thoracic vertebræ. (Testut.)

(B) The *Veins of the Spinal Cord,* of small size, run tortuously in the pia of the cord, and are disposed in longitudinal trunks over the median fissures and laterally, with plexiform communications between these trunks. Branches accompany the nerve-roots to the intervertebral foramina, where they join the lateral branches from the veins of the spinal canal. Superiorly they join the veins of the pons and cerebellum.

The principal blood-current through the veins of the spine is probably in a horizontal direction in the venous rings, formed by the communications between

the anterior and posterior veins, which send lateral branches through the intervertebral foramina.

THE INFERIOR VENA CAVA AND ITS TRIBUTARIES.

THE VEINS OF THE ABDOMEN (Fig. 544).

The **Inferior** or **Ascending Vena Cava** returns to the heart the blood from the lower extremities, the pelvis, and the abdomen, except that returned by the azygos and superior epigastric veins. It is a large vessel, which is formed by the union of the two common iliac veins in front of the right upper segment of

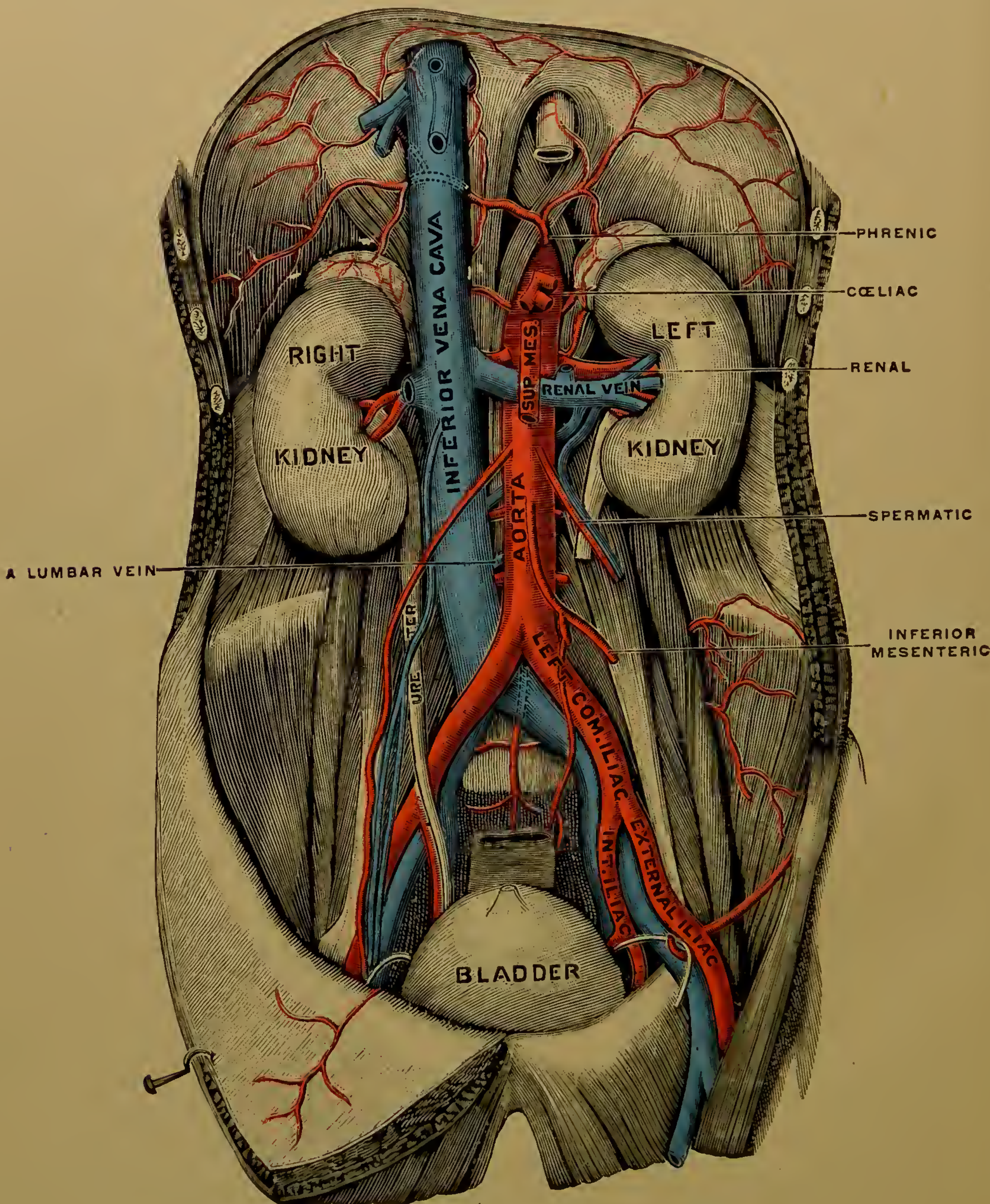


FIG. 544.—Inferior vena cava and its tributaries.

the fifth lumbar vertebra. Thence it runs upward to the right of the aorta, from which it is separated above by the right crus of the diaphragm and the Spigelian lobe of the liver as it inclines forward and lies in the groove or canal on the dorsal surface of the liver. On passing through the caval opening in the central tendon of the diaphragm, to the margins of which it is attached, it immediately

enters the pericardium. It then passes through the latter for about half an inch, only partly invested by its serous layer, to open into the lower and back part of the right auricle, opposite the upper border of the ninth thoracic vertebra. In the abdomen the liver, portal vein, pancreas, duodenum, mesentery, and right spermatic (or ovarian) artery, lie in front of it; the vertebræ, right renal and lumbar arteries, and the right crus of the diaphragm, behind it.

Tributaries.—The *hepatic veins* converge from the substance of the liver to the groove or canal occupied by the inferior vena cava, into which they empty in two or three trunks. The veins from the right and left lobes open so obliquely that the semilunar folds, presented at the lower border of their orifices, take the place of valves, which are otherwise wanting. These veins are of large size, and return the blood of the hepatic artery and the portal vein.

The *phrenic* (or *inferior phrenic*) *veins* accompany the phrenic arteries. The right one opens directly into the vena cava just below the diaphragm, while the left often joins the left suprarenal, or sometimes the left renal vein.

The *Suprarenal Veins.*—One vein on each side returns all the blood supplied by the three suprarenal arteries. The right vein terminates in the vena cava, the left in the left renal or phrenic vein.

The *renal veins* are large, short trunks, which run in front of the corresponding arteries from the hilum of the kidney to the vena cava, into which they empty nearly at right angles, the left a little above the right. The left renal vein is larger than the right. It has to cross the aorta, which it does just below the origin of the superior mesenteric artery, after receiving the spermatic (or ovarian) vein, often the suprarenal vein, and sometimes the phrenic vein of the same side. Rudimentary valves are found, especially on the left side. The shortness of the right renal vein should be remembered when dealing with the pedicle in nephrectomy.

The *spermatic veins* (Fig. 545) return the blood from the testicle and epididymis, from which they emerge dorsally, and, ascending to and through the inguinal canal, form a thick plexus (*pampiniform* ("tendril-shaped") *plexus*) in front of the vas deferens and the spermatic artery. On entering the abdomen through the internal abdominal ring the plexus merges into two or three veins, which accompany the spermatic artery beneath the peritoneum, on the psoas muscle and across the ureter. In their course they join to form a single trunk, which opens into the vena cava on the right side, and on the left side into the renal vein, which it meets at a right angle. Imperfect valves are found in the pampiniform plexuses, but the valve described at the termination of the vein may be absent in the vein of the left side, which moreover is usually slightly longer than the right vein and passes beneath the sigmoid colon, where it may be subjected to pressure.

The above differences are held to account for the greater frequency of varicocele on the left side. A few small veins ascend from the testicle behind the spermatic artery and the vas deferens and join the epigastric veins above. They are not ligated in the operation for varicocele.

The *ovarian veins* are homologous to the spermatic veins and terminate in the same manner. The *ovarian* or *pampiniform plexus*, in which they begin, lies near the ovary between the layers of the broad ligament, and communicates freely with the uterine plexus, as well as with the *ovarian bulb*, a plexus of fine veins at the hilum of the ovary. They follow the course of the ovarian arteries.

The *lumbar veins*, usually four in number on each side, accompany the lumbar arteries. They are formed by the union of ventral branches from the abdominal walls, where they communicate with the epigastric and internal mammary veins, and dorsal branches, which receive tributaries from the muscles of the back and the veins of the spine. The lumbar veins pass forward upon the bodies of the vertebræ beneath the psoas muscle, and on the left side beneath the aorta, to empty into the back of the vena cava. In front of the transverse processes and

behind the psoas muscle the lumbar veins of each side are connected by continuous vertical branches, called the *ascending lumbar vein*, which communicates below with the ilio-lumbar, common iliac, and lateral sacral veins, and is usually continued above as the azygos vein of the corresponding side.

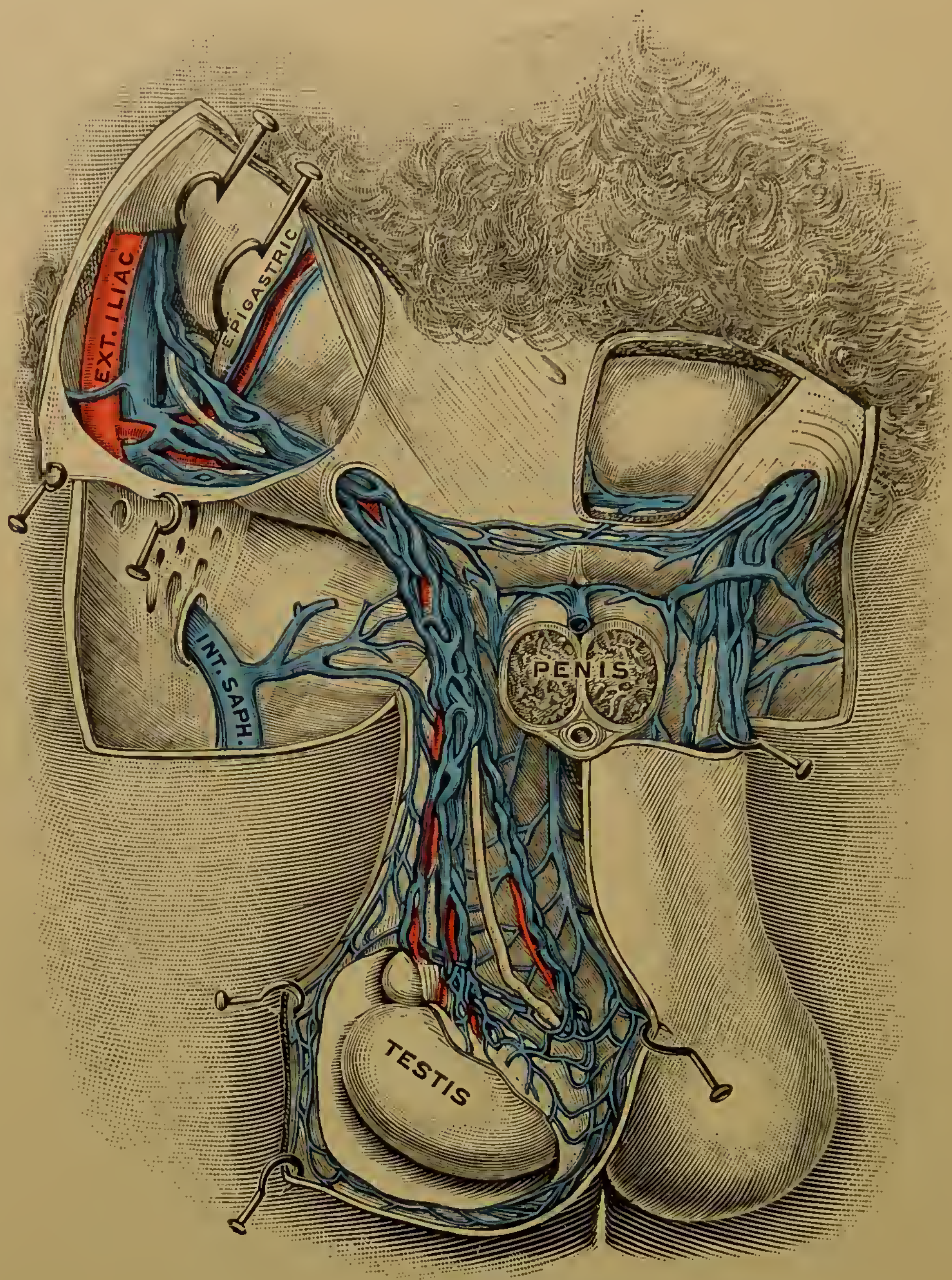


FIG. 545.—Spermatic veins. (Testut.)

The Common Iliac Veins.

The *Common Iliac Veins*, formed opposite the sacro-iliac articulations by the confluence of the internal and the external iliac veins, converge as they ascend, and unite opposite the right upper segment of the fifth lumbar vertebra to form the inferior vena cava. The *right vein*, shorter and more vertical than the left, lies behind and internal to its artery below, but above crosses obliquely behind it to its outer or right side, where it is joined by the *left vein*. The latter lies internal to the left common iliac artery and then crosses behind the upper end of the right artery to join the right vein. They contain no valves, except an occasional one in the left vein.

Tributaries.—The *ilio-lumbar veins* follow the ilio-lumbar arteries, and enter the common or internal iliac veins. They resemble the lumbar veins in their course, formation, and connections. The *middle sacral veins*, one on each side of the artery of the same name, ascend on the front of the sacrum to open into the left common iliac vein, after uniting into a single trunk. Occasionally this trunk enters the angle of junction of the two common iliac veins. These veins anastomose with the lateral sacral and the hemorrhoidal veins.

The External Iliac Vein (Fig. 546).

This is the continuation of the femoral vein, and extends from the level of the inguinal (Poupart's) ligament to the sacro-iliac articulation, where it joins the internal iliac vein. While it is internal to the artery on both sides below, on the

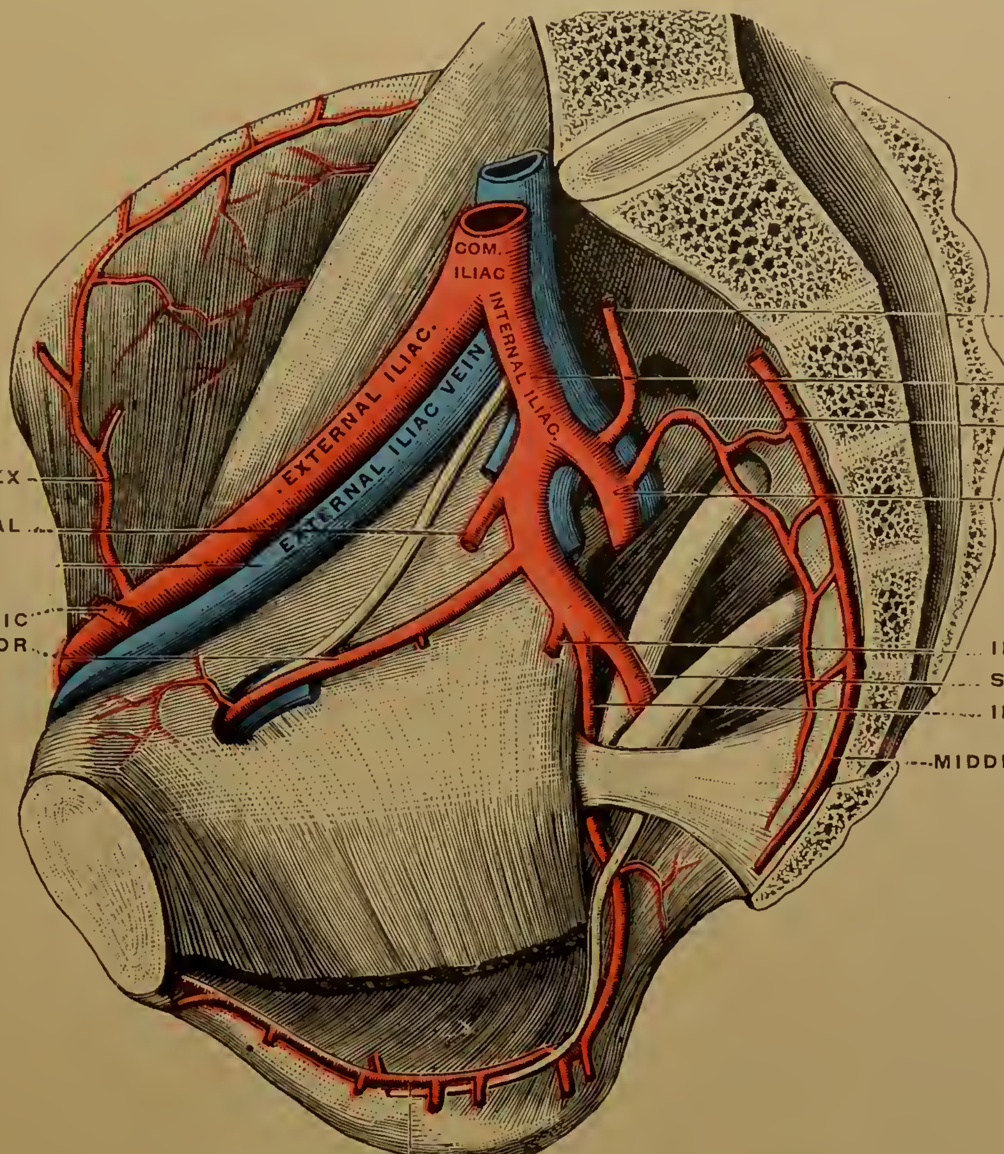


FIG. 546.—External iliac vein of right side. (Testut.)

right side above it inclines behind it. It contains one or two valves, and just above the inguinal ligament it receives the deep epigastric and the deep circumflex iliac veins, which accompany the corresponding arteries. A pubic vein, corresponding to the pubic branch of the obturator artery, ascends from the obturator vein to join the external iliac vein, and sometimes forms the main outlet of the obturator vein.

The Portal System of Veins (Fig. 547).

These are distinguished from other veins by beginning and ending in capillaries. The portal vein collects the blood from the chylopoiëtic viscera (the stomach, intestines, and pancreas), as well as from the spleen and the gall-bladder, and conveys it to the liver, to the capillaries of which it is distributed to be collected, together with the blood from the hepatic artery, by the hepatic veins, and so carried to the vena cava. The veins of this system have no valves.

The **Portal Vein** (*vena portæ*) (Fig. 548) is formed by the union of the splenic and the superior mesenteric veins, behind the upper end of the head of the pancreas, in front of the vena cava, and opposite the right side of the body of the first lumbar vertebra. From this point it runs upward and somewhat to the right for about three inches, to near the right end of the transverse fissure of the liver. Here it is somewhat enlarged (*sinus of the portal vein*), and divides into right and left branches, which enter their respective lobes and divide into

branches, in company with the hepatic artery and the hepatic duct. In its upward course it passes behind the first part of the duodenum, and then between the two layers of the right border of the small omentum, where it lies behind and between the hepatic artery on the left, and the common bile-duct on the right, and in front of the foramen of Winslow. These three structures, with the accompanying nerves and lymphatics, are enclosed by a connective-tissue sheath

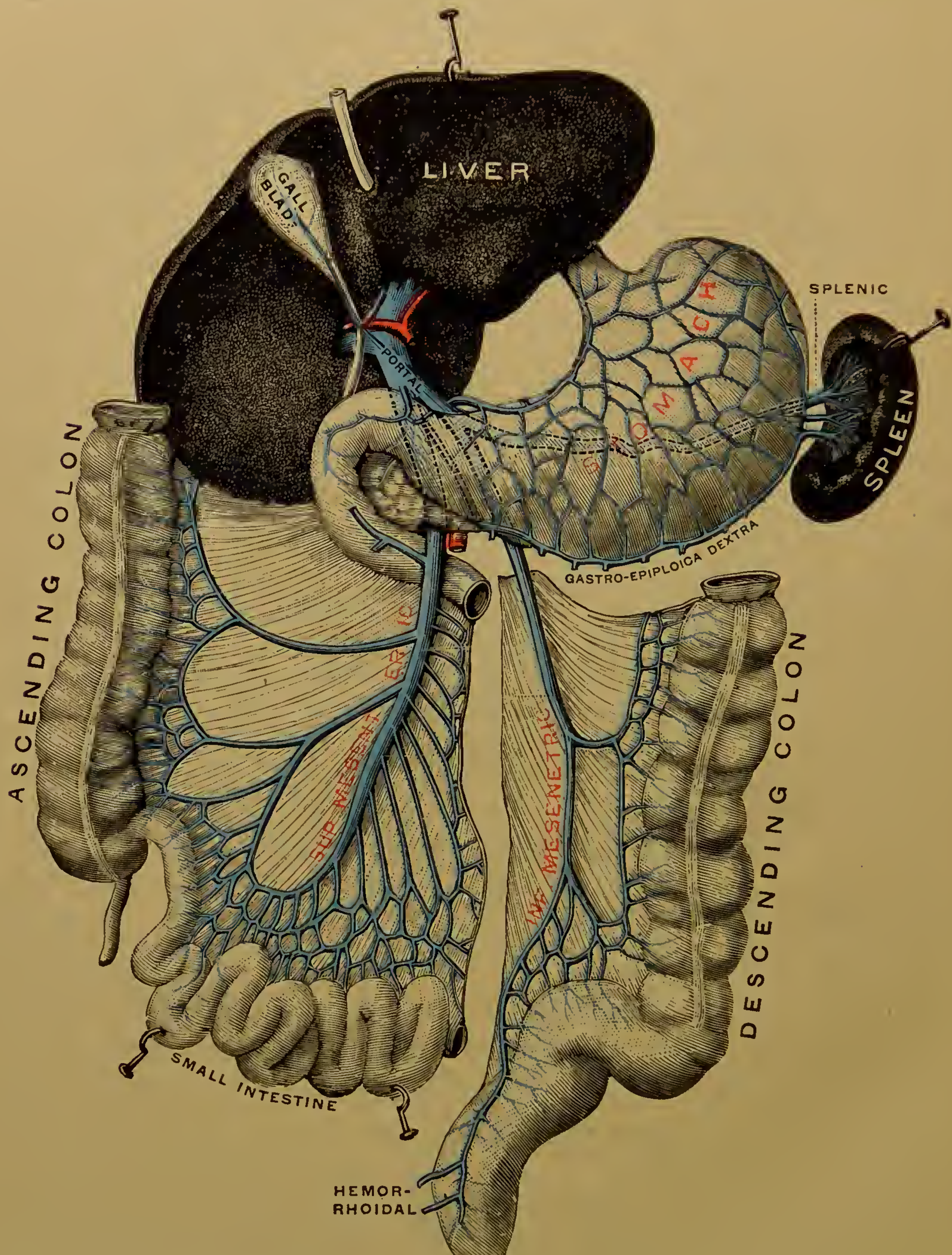


FIG. 547.—Portal system of veins. The liver is turned upward and backward, and the transverse colon and most of the small intestines are removed. (Testut.)

called the capsule of Glisson. The *left branch* is longer and smaller than the right, and where it crosses the umbilical fissure it is joined in front by the round ligament, the remains of the fœtal umbilical vein, and behind by another fibrous cord, the remains of the ductus venosus.

Tributaries.—Besides the superior mesenteric and the splenic veins, which by their union form the portal vein, the latter receives the pyloric and coronary veins from the stomach, and sometimes the cystic vein, which usually runs into the right branch.

The *Superior Mesenteric Vein* accompanies the corresponding artery, lying to the right and in front of it, and returns the blood from the parts supplied by it (the small intestine, cæcum, ascending and transverse colon) by radicles corresponding to the branches of the artery. It passes upward between the layers of the mesentery, and then in front of the third part of the duodenum and behind the pancreas, where, after receiving the *right gastro-epiploïc vein*, it joins the splenic vein to form the portal vein.

The *Inferior Mesenteric Vein* returns the blood from the rest of the large intestine (rectum, sigmoid flexure, and descending colon). Commencing in the hemorrhoidal plexus of the lower end of the rectum, where it freely anastomoses

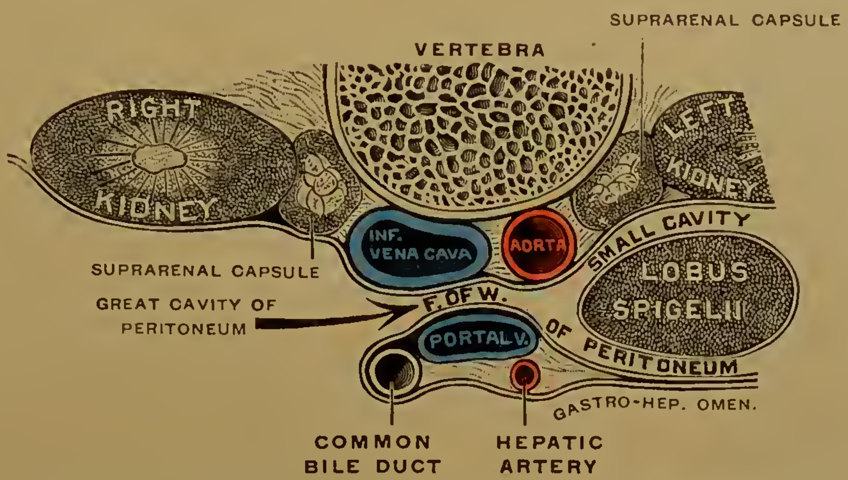


FIG. 548.—Transverse horizontal section through the foramen of Winslow, showing the relations of the portal vein. (Testut.)

with branches of the internal iliac vein, it passes up and out of the pelvis to the left of the inferior mesenteric artery. Above the origin of the latter it ascends, behind the peritoneum on the left side of the aorta, to the deep surface of the pancreas, where, inclining to the right, it joins the splenic vein near its termination.

The *Splenic Vein* is a vessel of large size, which passes from left to right below its companion artery, behind the pancreas. It commences by the union of several large branches from the hilum of the spleen, and ends, after crossing in front of the aorta, by joining the superior mesenteric vein, nearly at a right angle, to form the portal vein. It receives tributaries corresponding to the branches of the artery, and, in addition, the inferior mesenteric vein.

The *Pyloric Vein* is a small vessel which runs along the small curvature of the stomach from left to right in company with the (superior) pyloric artery. It opens into the lower part of the vena portæ.

The *Coronary* or *Gastric Vein* is a larger vessel, which accompanies the artery of the same name along the small curvature of the stomach from right to left. Near the cardiac orifice of the stomach it receives œsophageal veins and turns to the right across the spine, to end in the portal vein a little above the foregoing.

The Veins of the Pelvis.

The **Internal Iliac Veins** are short trunks without valves, which lie behind and to the inner side of the internal iliac arteries. They extend from the upper part of the great sacro-sciatic foramina to the sacro-iliac articulations, where they join the external iliac to form the common iliac veins. Each is formed by the union of veins corresponding to the branches of the internal iliac artery, excepting the *ilio-lumbar vein*, which opens into the common iliac vein, and the fœtal *umbilical veins*, which connect with the left branch of the portal vein.

The *Tributaries* correspond to the similar branches of the artery, except that the pudic vein does not begin in the dorsal vein of the penis, but in the veins of the corpus cavernosum.

The visceral veins are characterized by their large size, the number of their valves, and their frequent anastomoses, by which several connected plexuses are formed—*i. e.*, *prostatic*, *vesical*, *vaginal*, *uterine*, and *hemorrhoidal.*

The *Lateral Sacral Veins.*—These parietal tributaries also form a plexus, the *sacral plexus*, over the front of the sacrum, by anastomoses with one another and with the middle sacral veins. This plexus communicates with the veins of the spine through the anterior sacral foramina.

The *Dorsal Vein of the Penis* (Fig. 549), beginning in a plexiform circle of veins around the corona glandis, passes backward in the median dorsal groove of the penis, between the two dorsal arteries. At the root of the penis it continues backward through the suspensory ligament, and then through the triangular ligament, whereupon it divides into two lateral branches, which enter the prostatic plexus. It receives tributaries from the substance and surface of the penis. In front of the triangular ligament it communicates with the internal pudic veins. The dorsal vein may commence as two lateral vessels in front, which unite at a variable distance from the root of the penis.

Fig. 549.—Veins of the penis. (Testut.)

The *Gluteal, Sciatic, Obturator,* and *Internal Pudic Veins,* save for the exception above noted in the case of the internal pudic vein, correspond with the arteries and arterial branches which they accompany.

The *Prostatic Plexus* surrounds the prostate, especially at its base, sides, and in front, and lies beneath the sheath derived from the recto-vesical fascia. Besides the veins of the prostate it receives the dorsal vein of the penis in front, and communicates with the vesical and hemorrhoidal plexuses. It is frequently much enlarged and varicose in old men, and often contains phleboliths or vein-stones.

The *Vesical Plexus* surrounds the bladder beneath its peritoneal coat. It is particularly developed at the base and neck of the organ, where it communicates with the hemorrhoidal plexus, and with the prostatic plexus in the male, the vaginal plexus in the female. The prostatic and vesical plexuses open into the internal iliac veins by vessels passing from their lateral aspect. An abundant plexus of veins is often met with on the anterior surface of the bladder on opening that organ by the suprapubic incision.

The *Vaginal Plexus* surrounds the lower part of the vagina, and communicates with the vesical and hemorrhoidal plexuses and with the veins of the uterus.

The *Uterine Plexus* empties in part through the ovarian veins, and in part through the veins which accompany the uterine arteries. It is much enlarged during pregnancy.

The *Hemorrhoidal Plexus* lies beneath the mucous membrane of the lower part of the rectum. It communicates with the plexuses in front of it, and empties through the superior, middle and inferior hemorrhoidal veins, which accompany the arteries of the same name.

As the superior hemorrhoidal vein is a tributary of the portal system through the inferior mesenteric vein, and the other hemorrhoidal veins enter the internal iliac vein, a free anastomosis is thus established between the two

through this plexus. The veins of this plexus have no valves; hence the frequency of hemorrhoids from obstruction of the portal circulation in the liver.

VEINS OF THE LOWER EXTREMITY.

These, like the veins of the upper extremity, are divided into two sets, superficial and deep.

Superficial Veins of the Lower Extremity (Figs. 550–552).

These consist of two main trunks, internal and external, which commence in an arched plexus over the instep and on the dorsum of the foot, called the *dorsal plexus.*

The **Dorsal Plexus** receives the *dorsal digital veins* and branches from the small but numerous plexiform veins of the sole, which pass up behind the clefts of the toes and around the outer and inner borders of the foot. The veins are provided with numerous valves.

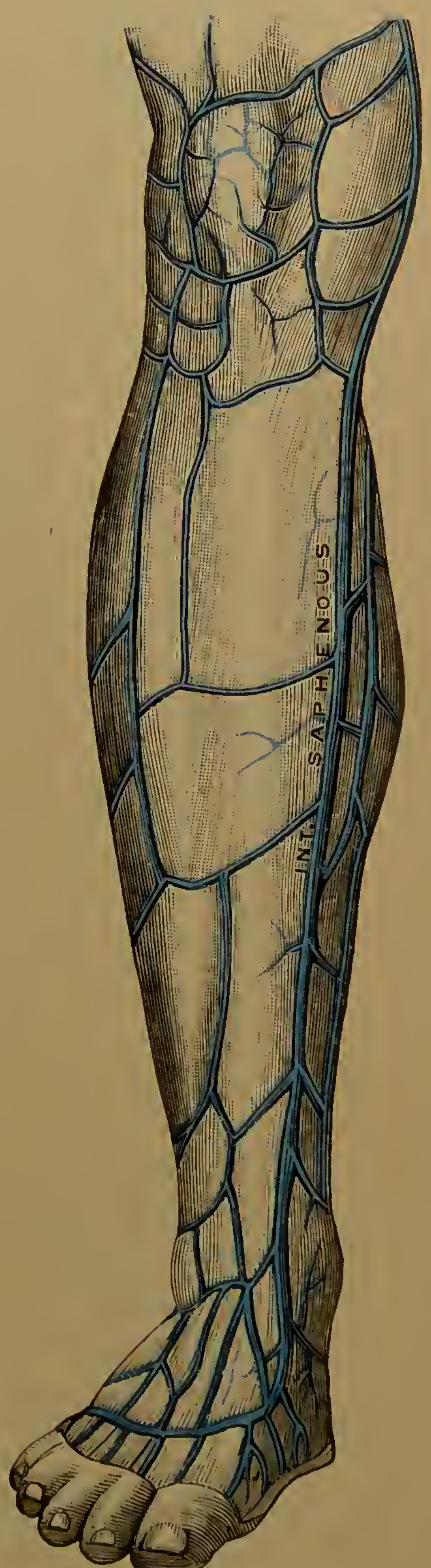


FIG. 550.—Superficial veins of the front of the leg and foot. (Testut.)

The **Internal** or **Long Saphenous Vein** commences at the inner part of the dorsal plexus, where it receives a vein of large size from the inner side of the great toe, and ends in the femoral vein an inch and a half below the inguinal ligament, after perforating the cribriform fascia of the saphenous opening. In its course it ascends in front of the internal malleolus, along the inner side of the leg, with the internal saphenous nerve, then behind the internal condyle of the femur, and finally upward, forward, and somewhat outward on the inner and forepart of the thigh. It is joined by various superficial tributaries along its course, by communicating branches from the deep veins of the sole, leg, and thigh, and, just below its termination, by the *superficial circumflex iliac, superficial epigastric,* and *external pudic veins,* which accompany the arteries of the same name, and also in many cases by a large anterior branch, which ascends over the front of the thigh. This vein contains from seven to twenty valves, more numerous in the thigh than in the leg.

The **External** or **Short Saphenous Vein**, commencing at the outer part of the dorsal plexus, ascends behind the external malleolus and then on the outer and back part of the leg, with the external saphenous nerve, to the lower part of the popliteal space, where it perforates the deep fascia, and ends in the popliteal vein.

Along its course it is joined by superficial radicles from the foot, the heel, and the back of the leg, and communicates with the deep veins at the ankle and in the leg. Near its termination a communicating branch usually runs upward and inward to the internal saphenous vein, and sometimes forms the main outlet of the external saphenous vein. This vein contains from nine to fourteen valves.

Deep Veins of the Lower Extremity.

Below the knee the deep veins accompany the respective arteries in pairs, as venæ comites.

The single **Popliteal Vein** is formed by the junction of the venæ comites of the anterior and posterior tibial arteries, near the lower border of the popliteus

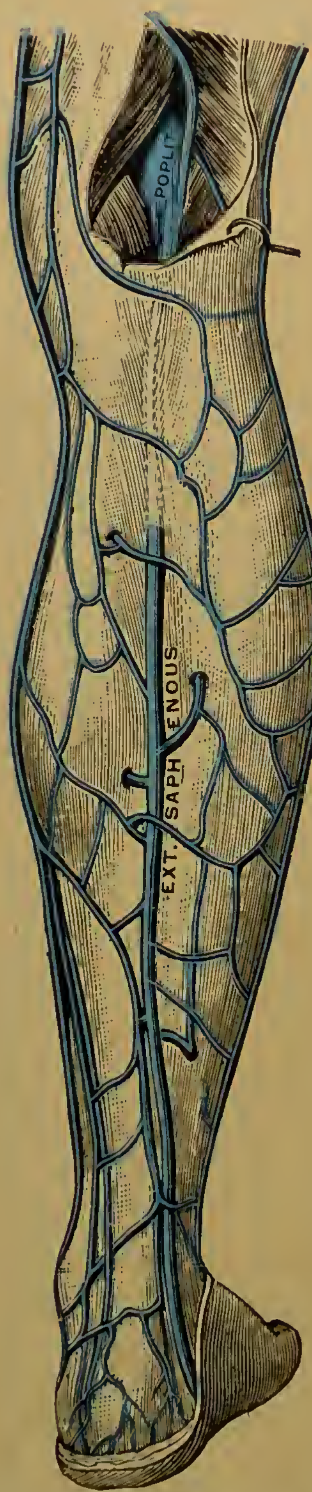


Fig. 551.—Superficial veins of the dorsum of the leg. (Testut.)

Fig. 552.—Superficial veins of the front of the right thigh. (Testut.)

muscle. This vein lies superficial to its artery throughout, internal to it below, and external to it above, after crossing it obliquely. It receives radicles corresponding to the branches of the artery, and in addition the external saphenous vein. Two or three valves are usually present. After passing with its artery through the opening in the adductor magnus, it is continued as the **Femoral Vein** up to the level of the inguinal ligament. Below, in Hunter's canal, the femoral vein lies behind and somewhat to the outer side of its artery, but, as it ascends, it

crosses obliquely behind the artery, so as to be internal to it in the upper part of Scarpa's triangle. It is joined by tributaries corresponding to the branches of the artery, except for the tributaries named as joining the upper end of the internal saphenous vein. Its tributaries include the *Deep Femoral Vein* (which ascends in front of its artery), and also, near its upper end, the internal saphenous vein. It contains three or four valves, one of which is just above the opening of the deep femoral vein, and another just below the inguinal ligament. At its upper end it is separated internally from the crural canal by a thin septum of fascia, passing between the front and rear walls of the femoral sheath.

THE FŒTAL CIRCULATION.

As the fœtus in the womb cannot use its alimentary tube or its respiratory apparatus for purposes of sustenance as the child does after birth, its support is accomplished by means of modifications in the blood-vascular system, certain devices being introduced which serve a temporary purpose, and, when no longer of use, are suppressed. These parts are the placenta and umbilical cord, which are outside of the body of the fœtus; and the continuation of the umbilical vein, the ductus venosus, the Eustachian valve, the foramen ovale, the ductus arteriosus, and the hypogastric arteries, which are contained in the body of the fœtus. After birth the extrafœtal parts decompose; the foramen ovale is closed; the Eustachian valve dwindles until, in the mature body, it is difficult to detect it; and the umbilical vein, the ductus venosus, the ductus arteriosus, and the hypogastric arteries shrink away into impervious, fibrous cords.

The *placenta* is an organ developed in the early part of pregnancy in close union with the inner surface of the uterus. It is composed of blood-vessels, and through it an interchange takes place between the blood of the mother and that of the developing child—the parent furnishing nutritious materials, the fœtus giving up those that are excrementitious.

The blood is carried from the placenta through the umbilical cord to the fœtus by the *umbilical vein*, which enters at the navel, and goes upward in the free margin of the falciform ligament to the anterior border of the liver. It runs in the umbilical fissure on the under surface of the liver, giving branches on its way to the left portions of the gland, and at the transverse fissure a large branch, which unites with the portal vein. From this point the umbilical vein is called the *ductus venosus*, and runs in the fissure at the left of the Spigelian lobe, leaving this to empty into the inferior vena cava, which receives also from the liver through the hepatic veins the blood brought into that organ by the umbilical and portal veins combined, and that which was distributed to its left portion. The inferior vena cava conveys from the lower limbs and the lower part of the trunk impure blood, which is now mingled with that from the liver, and the mixed stream flows to the right auricle of the heart. Entering at the lower part of this cavity, it is guided by the *Eustachian valve*, which is very large in the fœtus, across the cavity, through the *foramen ovale* into the left auricle, where a little impure blood from the pulmonary veins is mingled with it. It then passes into the left ventricle, and thence into the aorta, which carries almost all of it through the great branches of the arch to the head, neck, and upper limbs, though a little goes into the descending aorta and to the parts supplied by it. From the head, neck, and upper limbs the blood is returned through the superior vena cava to the right auricle, through which it passes with little or no mingling with the crossing stream from the inferior vena cava, enters the right ventricle, and is driven thence into the pulmonary artery. Only a little of this blood is sent to the lungs, however, these organs being functionless at this period; but almost all of it passes through the *ductus arteriosus*, a vessel connecting the pulmonary artery at its bifurcation with the descending portion of the aortic arch. From the aorta a small part of the blood is carried to the lower limbs and the lower

part of the trunk, the greatest part passing by way of the anterior trunk of the internal iliac arteries through the *hypogastric arteries* which run to the sides and apex of the bladder, thence upward to the navel, at which they leave the fœtus, becoming the *umbilical arteries*, and, twining spirally around the umbilical vein, go to the placenta.

It will thus be seen that the tissues of the fœtus are nowhere furnished with perfectly pure blood. That which reaches the head, neck, and upper limbs is the best, and this fact accounts for their much better development at birth than is shown by the lower part of the body and the lower limbs.